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NATIONAL DEFENSE RESEARCH COMMITTEE

DIVISION 6 - SECTION 6.1

AN/ASQ-1
MAGNETIC AIRBORNE DETECTION EQUIPMENT

AIRBORNE INSTRUMENTS LABORATORY
COLUMBIA UNIVERSITY
DIVISION OF WAR RESEARCH

COPY NO. 24

OCTOBER 1943

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Office of Scientific Research and Development
Division 6 Section 6.1
National Defense Research Committee

AN/ASQ-1

MAGNETIC AIRBORNE

DETECTION EQUIPMENT

Airborne Instruments Laboratory
Mineola, New York

Submitted for Airborne Instruments Laboratory
Under Letter of Intent, Symbol No. 3280

By D. G. Ostare, Director

Approved for Distribution

By John T. Tate, Chief of Division Six

OSRD No. OEMsr-1129
Section 6.1 - ~~S3280~~ - 813

October 19, 1943

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MAGNETIC AIRBORNE
DETECTION EQUIPMENT

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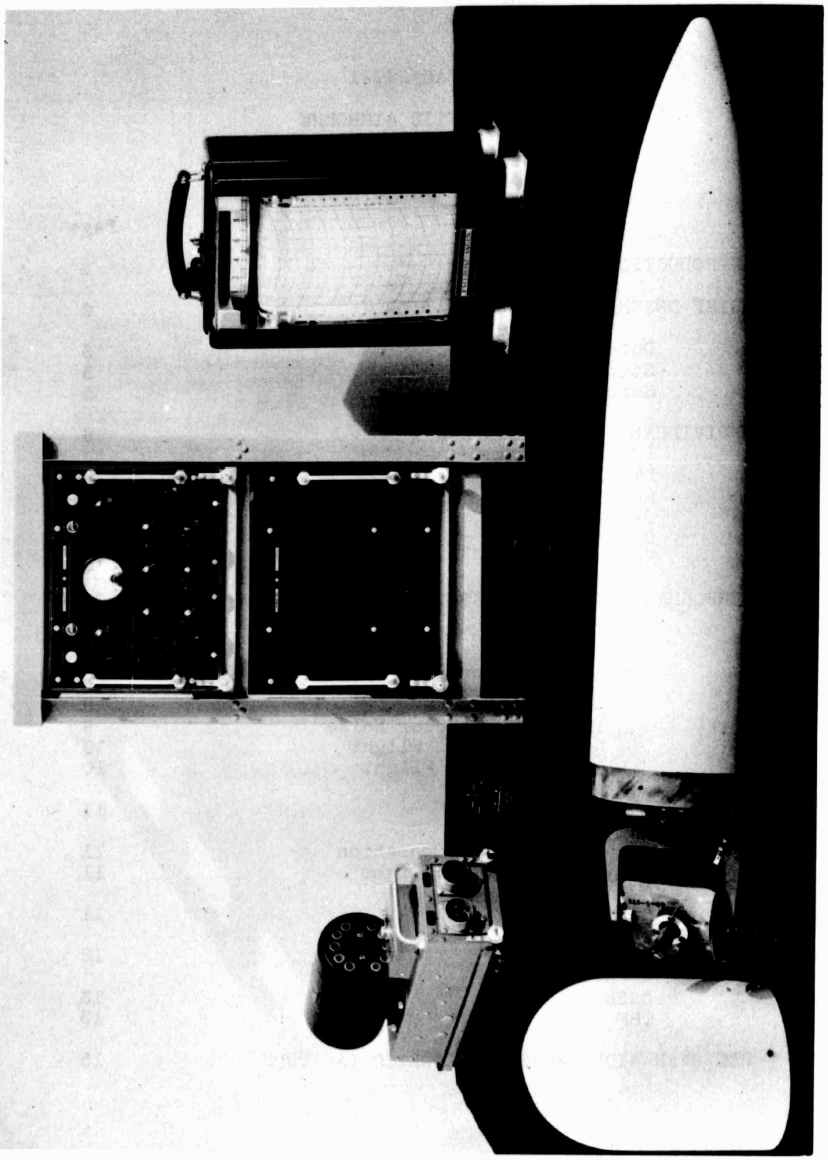

AN/ASQ-1 EQUIPMENT
FIGURE 1

AN/ASQ-1

MAGNETIC AIRBORNE

DETECTION EQUIPMENT

The AN/ASQ-1 is a sensitive stabilized recording magnetometer designed for installation in aircraft. The equipment is used to locate submerged submarines by detecting the small local changes produced by the submarines in the magnetic field of the earth. The normal range of detection varies from 400 to 700 feet. This range is the subject of a separate report which will show how the range of detection depends upon the several factors involved.

The AN/ASQ-1 was designed on the basis of experience gained in the construction, testing, and operation of a substantial number of the previous model (MAD Mark IV-B2). The new equipment is lighter in weight, smaller in size, and comprises fewer individual units. Aside from the reduced size and weight, AN/ASQ-1 has the advantage that all controls are on one unit. This makes for more convenient installation and operation since only this unit need be within reach of the operator while the remaining units may be installed wherever space considerations indicate.

Figure 1 shows the complete AN/ASQ-1 equipment. The equipment occupies 3.9 cubic feet of space and has a normal installed weight of 135 pounds including installation accessories in contrast to the 6.5 cubic feet and 260 pounds for the Mark IV-B2 equipment. The AN/ASQ-1 is designed to operate from a 24-volt battery source which may supply up to 28 volts while being charged, but the equipment operates equally well with any supply between 22 and 29 volts. The output is insensitive to sudden changes of the supply voltage within this range. The current consumption is 11.5 amperes at 22 volts and 12.4 amperes at 29 volts. No additional batteries are required for plate supply.

BRIEF DESCRIPTION OF OPERATION

The magnetically sensitive detector element of AN/ASQ-1 is of the saturable core type and employs a single elongated permalloy core with two windings. Since the detector element is responsive only to the magnetic field component in the direction of its length, stabilization of the orientation of the detector element is necessary. If the detector element were not stabilized, the angular motions of the aircraft in which the equipment is installed would change the angle made by the detector element with the earth's magnetic field and thereby change the value of the magnetic field component in the direction of the length of the detector element. Such changes would completely mask the small field changes it is desired to detect. The detector element is mounted in a gimbal arrangement embodying two axes of rotation at right angles. Rotations about the two axes are produced by two servo-motors controlled by the outputs of two auxiliary magnetically sensitive elements mounted at right angles to each other and at right angles to the detector element. Each stabilizer element controls one servo-motor so as to maintain itself at right angles to the earth's magnetic field. In this way, the detector element is maintained parallel to the direction of the earth's magnetic field even during rapid maneuvers of the aircraft. Each stabilizer element is of the same type as the detector element but consists of two slender permalloy cores with one coil on each core. The four cores of the stabilizer elements are arranged in the form of a square around the detector element. With this construction, the size and weight of the moving assembly are greatly reduced. The gimbal mounting, containing the detector and stabilizer elements, is referred to as the magnetometer head.

Figure 2 shows a simplified diagram of the AN/ASQ-1 equipment on which the separate circuit sections are represented by rectangles.

AN/ASQ-1 is a single frequency system. That is, the detector element, the stabilizer elements, and the servo-motors are all supplied with power at a single frequency which originates in the master oscillator. This oscillator has been especially designed for high stability both as to amplitude and frequency of its output. Its output is a remarkably pure sinusoidal voltage at a stabilized frequency of 400 cycles per second. The oscillator is inherently insensitive to temperature changes.

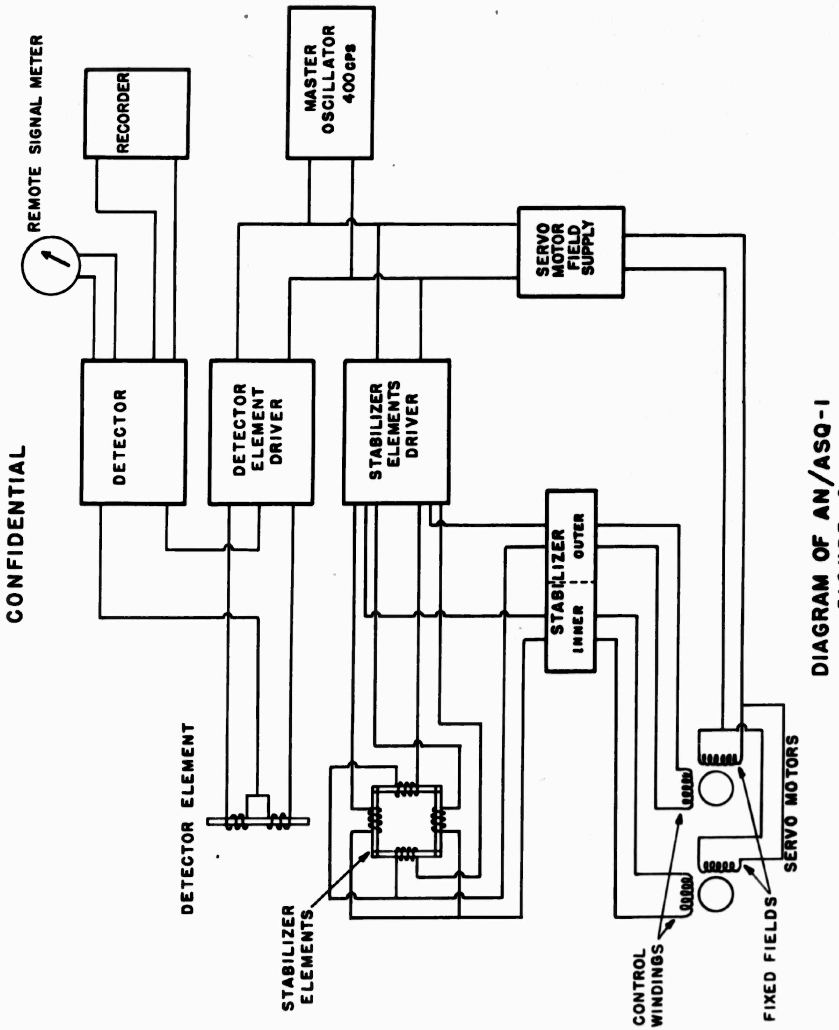

DIAGRAM OF AN/ASQ-1
FIGURE 2

DETECTOR SYSTEM

The detector element driver is essentially a high quality push-pull power amplifier for furnishing the necessary driving power to the detector element. The design of this amplifier is such as to minimize the effects of microphonics, and special features are incorporated which render its output insensitive to temperature changes and to variations in heater current of the vacuum tubes. The output of the detector element driver is supplied to the coils of the detector element. Means are provided for passing a small direct current through the same coils to produce in the permalloy core a steady magnetic field equal in magnitude but opposite in direction to that produced in the core by the magnetic field of the earth. The resultant steady magnetic field in the core is essentially zero. In this balanced condition, the output of the detector element consists of a succession of sharp voltage peaks of the same magnitude and equally spaced in time, but successive peaks are of opposite polarity. Since the drive frequency is 400 cycles, there are 400 positive and 400 negative peaks per second. If the earth's magnetic field changes by a small amount, the peaks of one polarity increase in size, while those of opposite polarity become smaller. The magnetic field variations appear as variations of the envelopes of the positive and negative peaks.

The output of the detector element goes to the detector. In the detector, the positive and negative peaks are separately demodulated to give the two envelope voltages. The difference between the two envelope voltages is amplified by a balanced low-frequency amplifier having an appropriate response-frequency characteristic. The detector circuit chosen has been carefully designed for stability and freedom from microphonic effects.

The output of the detector goes to the ink-writing recorder which writes a continuous record of the signal output and to the remote signal meter which is an aircraft-type milliammeter and gives instantaneous signal indications.

STABILIZER SYSTEM

The stabilizer element driver is a high quality push-pull power amplifier similar to the detector element driver and supplies 400-cycle power to both stabilizer elements. Each stabilizer element in its normal position is perpendicular to the direction of the earth's magnetic field so that the steady magnetic field in the direction

of the length of its cores is essentially zero. The output of a stabilizer element in this condition, like the output of the detector element when precisely balanced, consists of a succession of sharp voltage peaks of equal magnitude, but successive peaks are of opposite polarity. If the stabilizer element is rotated slightly so that it is no longer perpendicular to the earth's magnetic field, the peaks of one polarity will increase in size and those of the opposite polarity will decrease. Which set of peaks will increase is determined by the direction the stabilizer element was rotated from its normal position.

The output of each stabilizer element goes to one of the two identical channels of the stabilizer. In the first stage of each channel of the stabilizer, the output of the corresponding stabilizer element is rectified so that the output of this first stage consists of a succession of voltage peaks, all of the same polarity. These peaks occur at the rate of 800 per second. When the stabilizer element is in its normal position, these peaks all have the same magnitude, but if the stabilizer element is turned through a small angle from its normal position, every other voltage peak increases in size and the intermediate peaks decrease. The remainder of each channel of the stabilizer is essentially a selective amplifier tuned to 400 cycles per second.

When a stabilizer element is in its normal position, perpendicular to the earth's magnetic field, the input to this selective amplifier is the succession of like peaks which recur at the rate of 800 per second. Such an input contains no sinusoidal component of lower frequency than 800 cycles per second, so that, due to the selective nature of the stabilizer, its output is a greatly attenuated sinusoidal voltage at 800 cycles per second. However, if the stabilizer element is turned slightly from its normal position, the input to the selective amplifier becomes the succession of peaks of alternately greater and less magnitude. This input contains a sinusoidal component of 400 cycles per second which the amplifier is designed to transmit. The magnitude of this component is proportional to the angle through which the stabilizer element was displaced, and its phase has one of two values, differing by 180°, depending upon the direction of deflection of the stabilizer element from its normal position.

The output of each stabilizer channel goes to the control winding of one of two identical two-phase motors whose field windings are constantly supplied with 400-cycle power. When a stabilizer element is in its normal position the corresponding motor develops no torque because of the difference in frequency between the two applied voltages. But if the stabilizer element is displaced in either direction the stabilizer channel output has the same frequency as the constant field supply and the motor develops torque. If the displacement is in one direction, the output of the stabilizer channel leads the constant field supply by 90° and the motor, which is coupled to the magnetometer head, rotates in such a direction as to restore the stabilizer element to its normal position. If the displacement is in the opposite direction the output of the stabilizer channel lags the constant field supply by 90° and the motor rotates in the opposite direction which is, again, the direction which will restore the stabilizer element to its normal position.

The constant fields of the two motors are supplied with 400-cycle power from the servo-motor field supply which is a power amplifier energized by the master oscillator. Each channel of the stabilization system taken as a whole consists of a stabilizer element, one channel of the stabilizer, and one servo-motor. The two channels are referred to as "inner" and "outer" since they control the rotation of the detector element about the inner and outer mechanical axes of the magnetometer head. The two channels operate independently without interaction and maintain the detector element in a fixed direction even during rapid maneuvers of the aircraft in which the AN/ASQ-1 equipment is installed.

SAMPLE RECORDS

Figures 3 and 4 show signals recorded by AN/ASQ-1 equipment above a submerged submarine. The airplane in which the equipment was installed flew at 100 feet above the water and made successive passages over the vicinity of the moving submarine which was submerged to a depth of 100 feet. On these records the submarine signals are marked by arrows. Time progresses from left to right and the interval between lines is 30 seconds. Of the two submarine signals shown in Figure 3, the second is large and was recorded as the airplane flew almost directly over the submarine while the first signal was recorded on a

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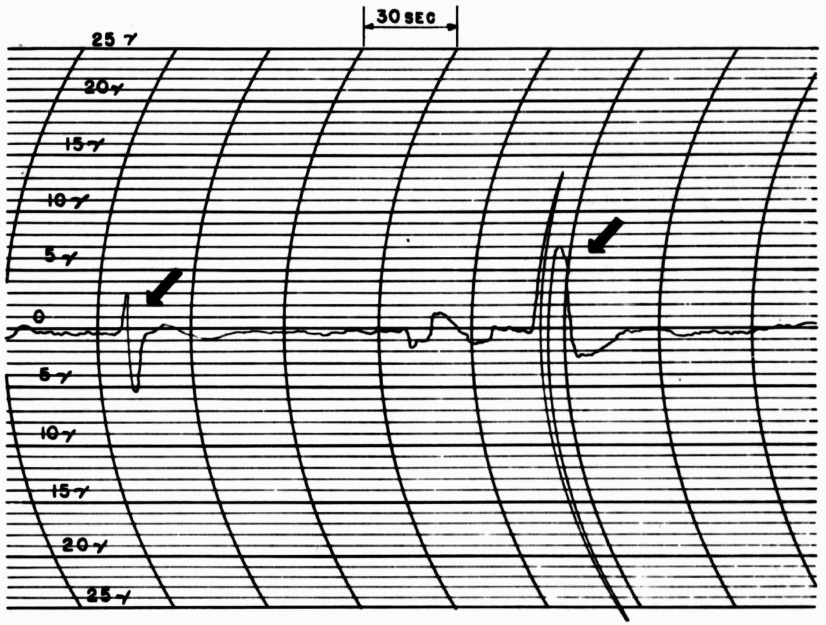
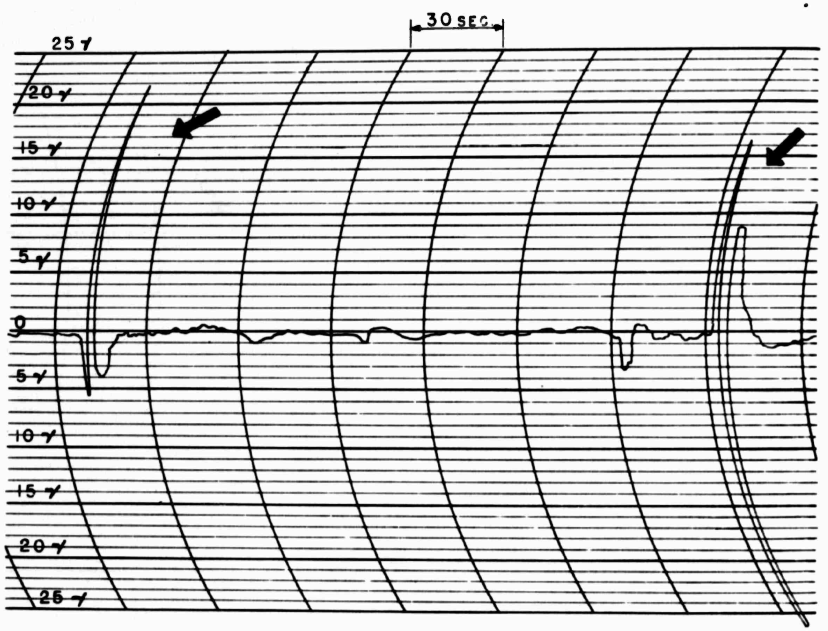


AN/ASQ-1 SIGNALS RECORDED ABOVE A SUBMERGED SUBMARINE

FIGURE 3



AN/ASQ-1 SIGNALS RECORDED
ABOVE A SUBMERGED SUBMARINE

FIGURE 4

passage considerably to one side of the submarine and is accordingly smaller. The two signals of Figure 4 are of different character because the angle of approach of the airplane was different in the two cases.

Figure 5 shows an AN/ASQ-1 signal recorded at an altitude of 400 feet from a sunken tanker resting on the bottom in shallow water. When this record was made, the detector gain was adjusted to a lower sensitivity than was used when the records of Figures 3 and 4 were made.

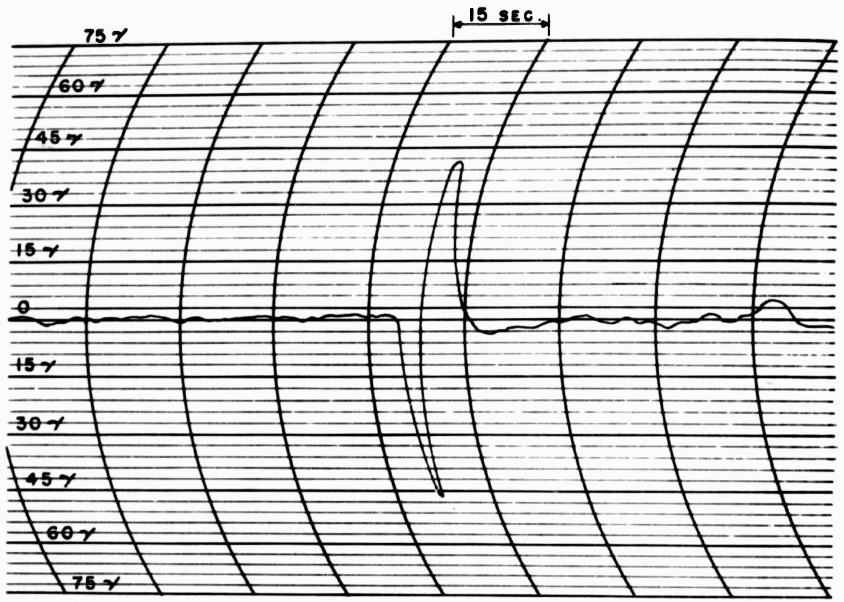
INDIVIDUAL UNITS OF AN/ASQ-1

The AN/ASQ-1 equipment, aside from the recorder and remote signal meter, is contained in only four separate units. Figure 6 shows the distribution of circuit sections among the units.

DT-1/ASQ-1

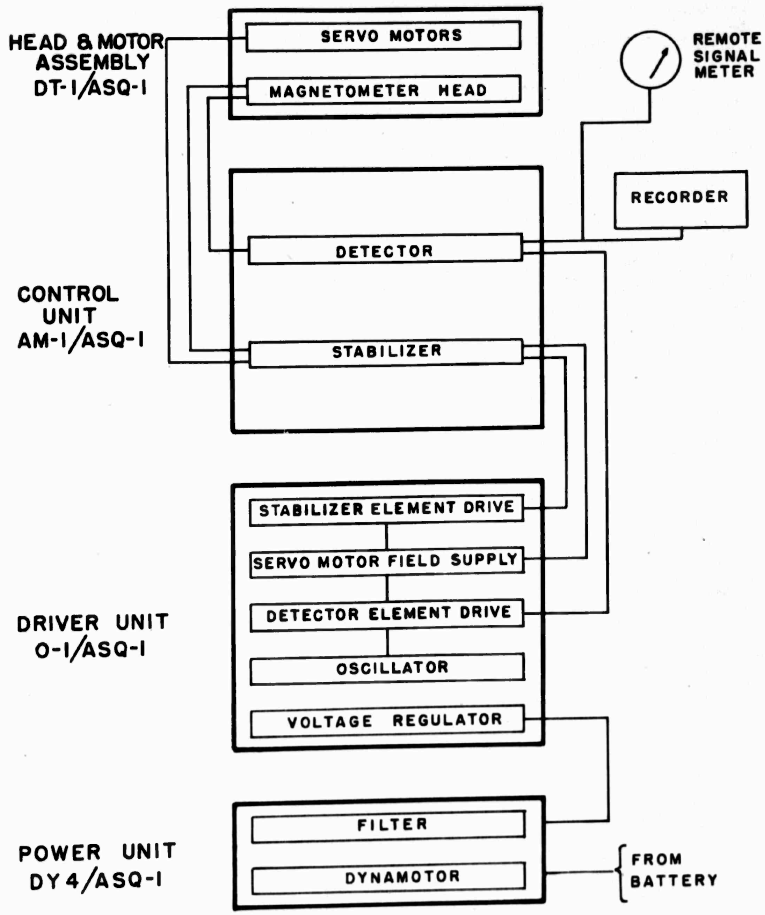
The magnetometer head and motor assembly, DT-1/ASQ-1, shown in Figure 7, has been designed as a single unit to fit inside a streamlined body 7-1/8 inches in maximum diameter and 42 inches long. Figure 8 shows the unit mounted in the streamlined housing which has been cut away to show the assembly. The housing protects the unit and makes for more convenient installation. The magnetometer head is shown in Figure 9. The detector element is sealed in the cylindrical tube, and the stabilizer elements are mounted on the square plate around the detector element. The magnetometer head has been made considerably smaller than the one used in the IV-B2 equipment without sacrifice of sensitivity or precision of stabilizer control. In the design and production of the magnetometer head, adequate attention has been given to the questions of mechanical dependability, aging characteristics, and temperature effects. The magnetometer head is designed and tested for operation at temperatures of from -200F to 140°F. The method and materials used in mounting the permalloy cores were chosen after careful tests of possible methods and materials.

The motor end of DT-1/ASQ-1 is shown in Figure 10. The motors are two-phase Kollsman motors (No.776-04) which are smaller and more efficient than the motors



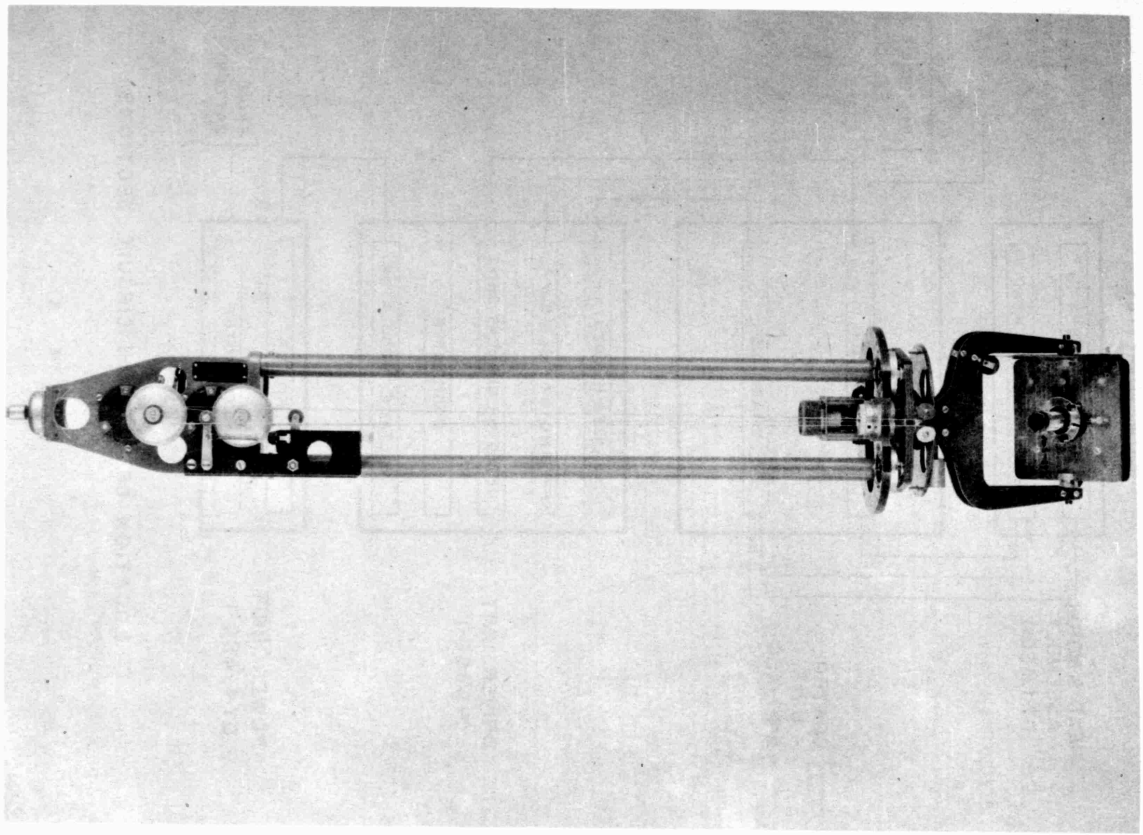
AN/ASQ-1 SIGNAL RECORDED
ABOVE A SUNKEN TANKER

FIGURE 5



LOCATION OF AN/ASQ-1 CIRCUIT SECTIONS

FIGURE 6



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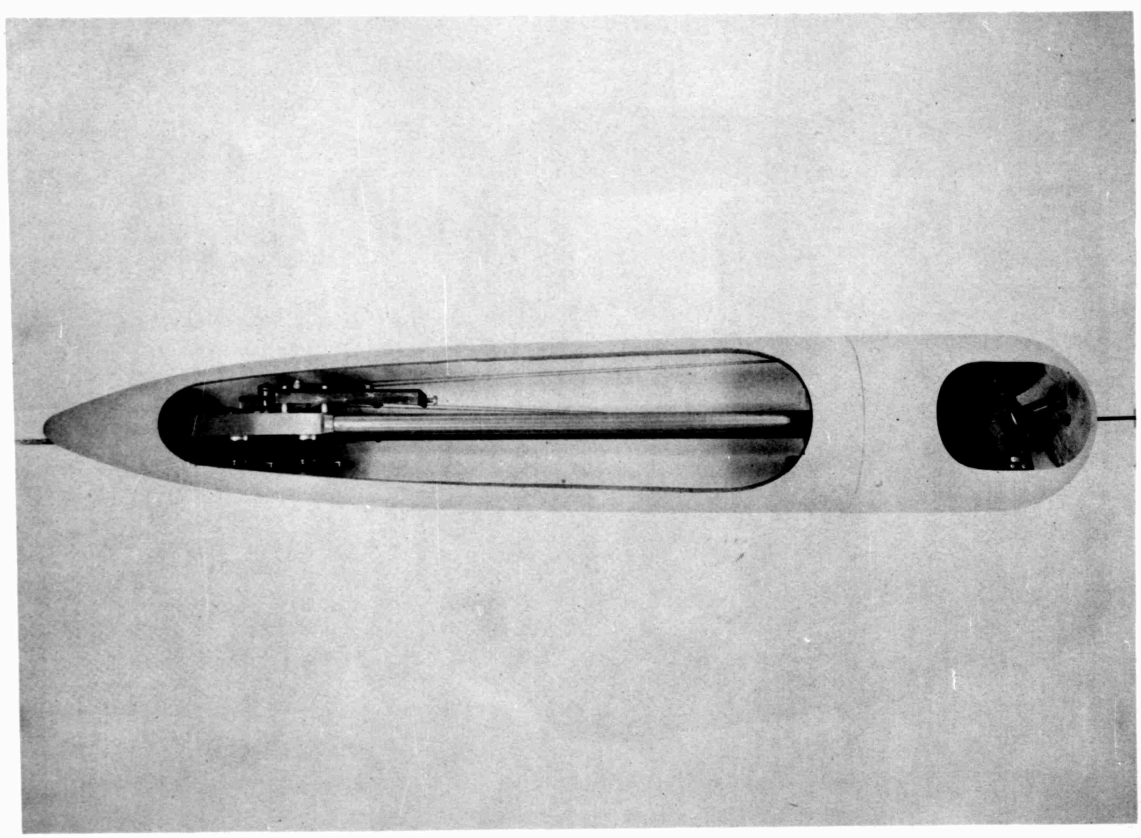
MAGNETOMETER HEAD & MOTOR ASSEMBLY DT-1/ASQ-1
FIGURE 7



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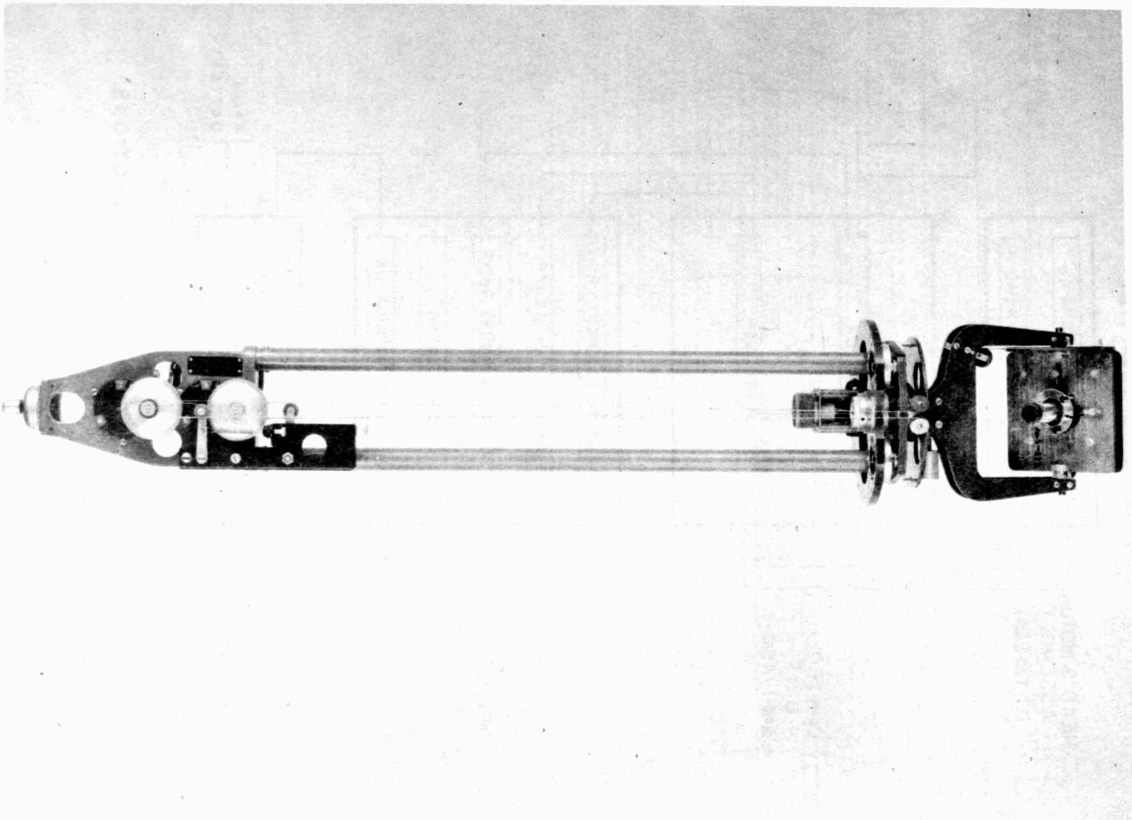
DT-1/ASQ-1 IN CUTAWAY HOUSING
FIGURE 8



MAGNETOMETER HEAD & MOTOR ASSEMBLY DT-1/ASQ-1
FIGURE 7

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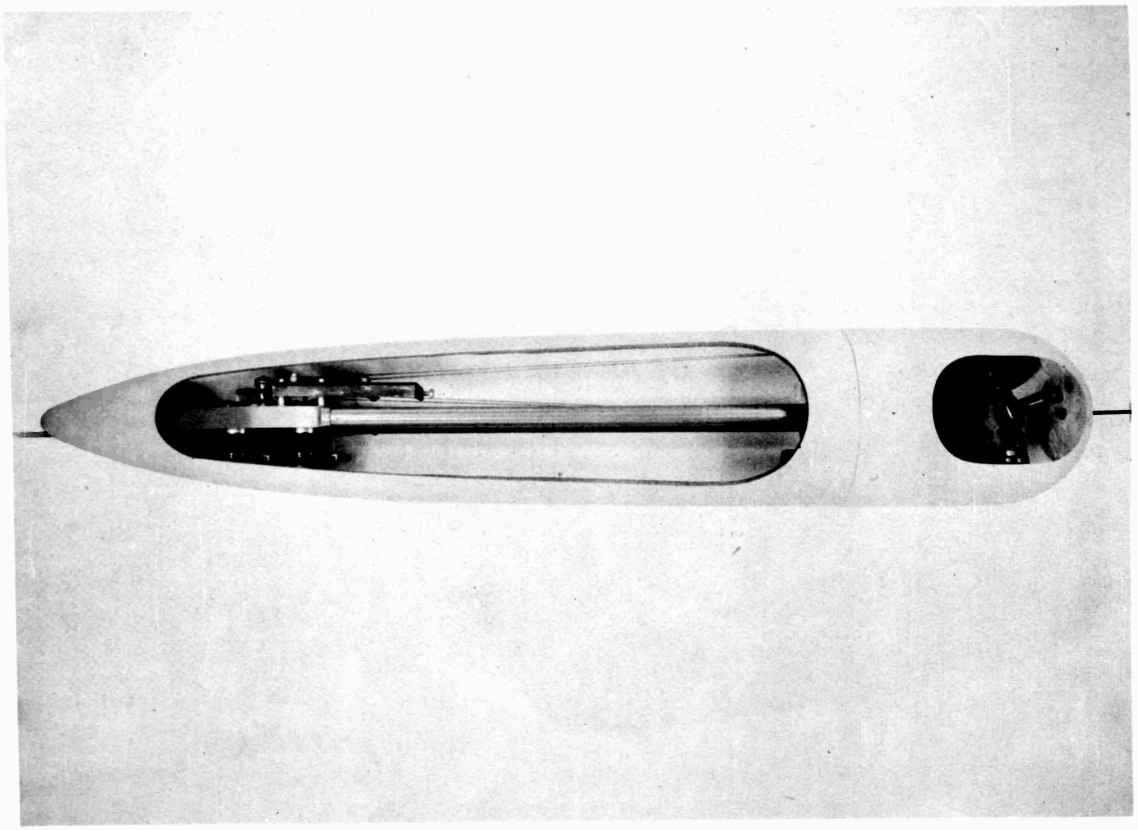
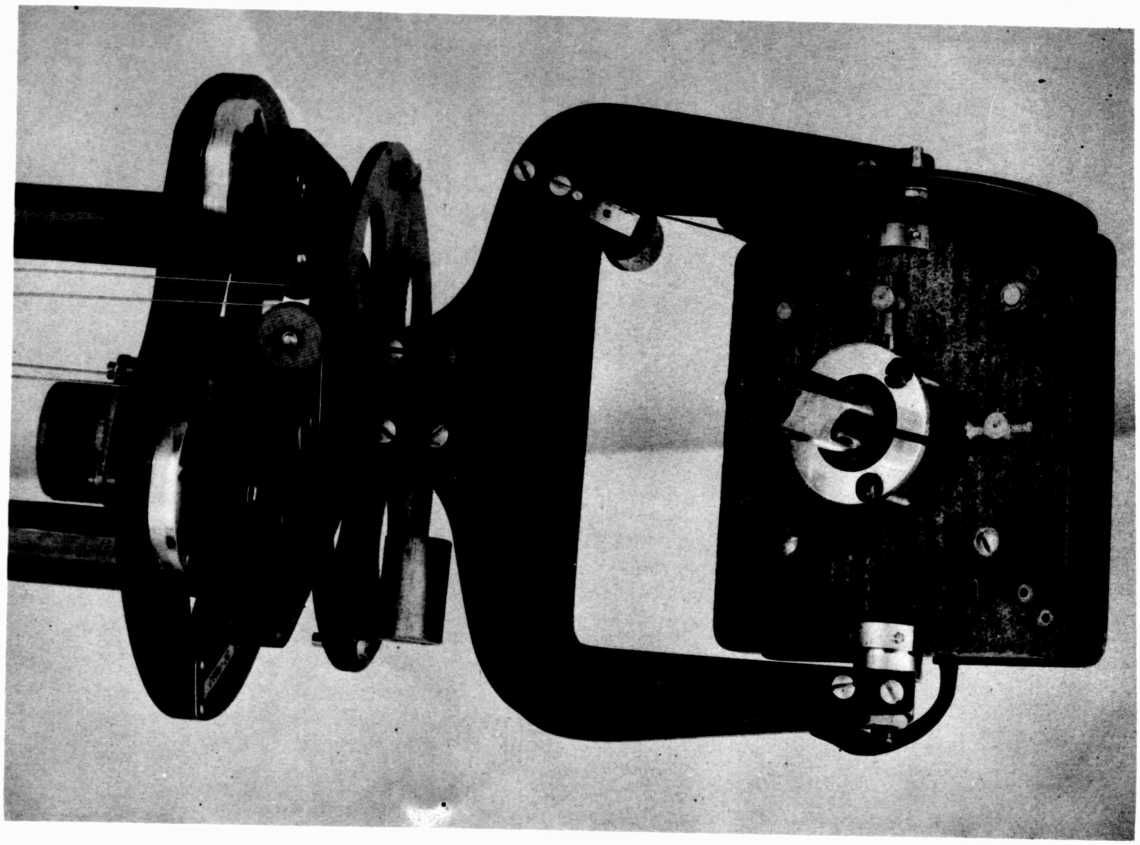
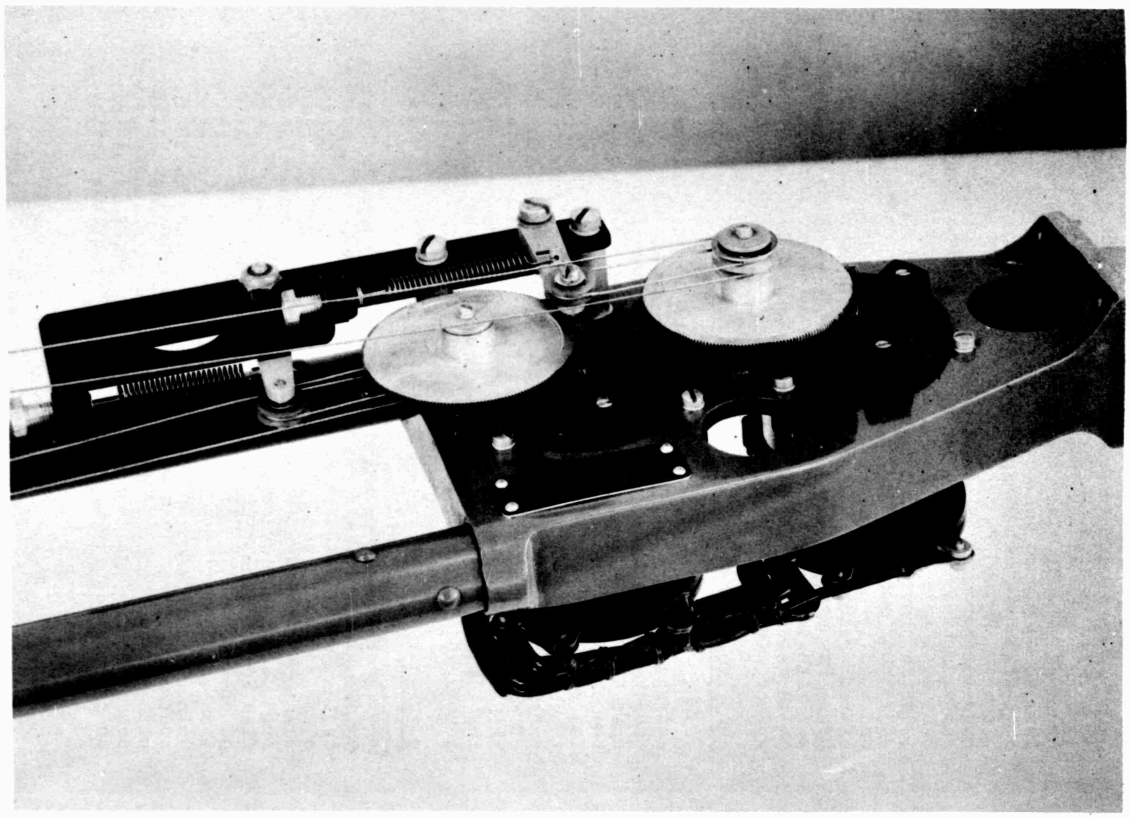


DT-1/ASQ-1 IN CUTAWAY HOUSING
FIGURE 8



MAGNETOMETER HEAD
FIGURE 9



MOTOR END OF DT-1/ASQ-1
FIGURE 10

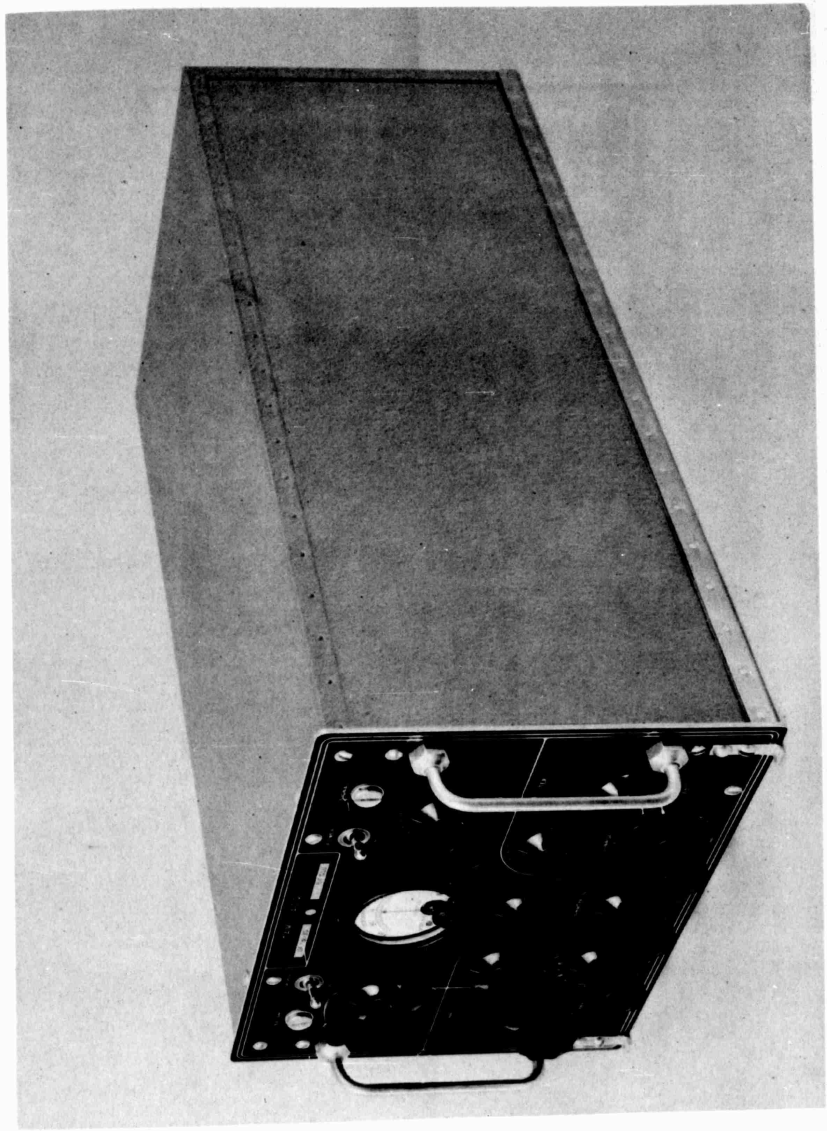
previously used. They also contain less iron which allows them to be placed considerably closer to the magnetometer head without causing magnetic disturbances at the detector element. Motion is transmitted from the motors to the magnetometer head by means of belts which consist of 49 cabled strands of 0.003-inch phosphor-bronze chosen as the best available material. A spring-actuated tensioning idler is provided for each belt which simplifies tension adjustment and insures that the belt tension will remain essentially constant as the belt length changes because of temperature variations or because of wear through long use. The motors, idler pulleys, and gears are all equipped with ball-bearings which result in lower friction and better servo operation. The weight of DT-1/ASQ-1, together with the streamlined housing, is 9 pounds.

AM-1/ASQ-1

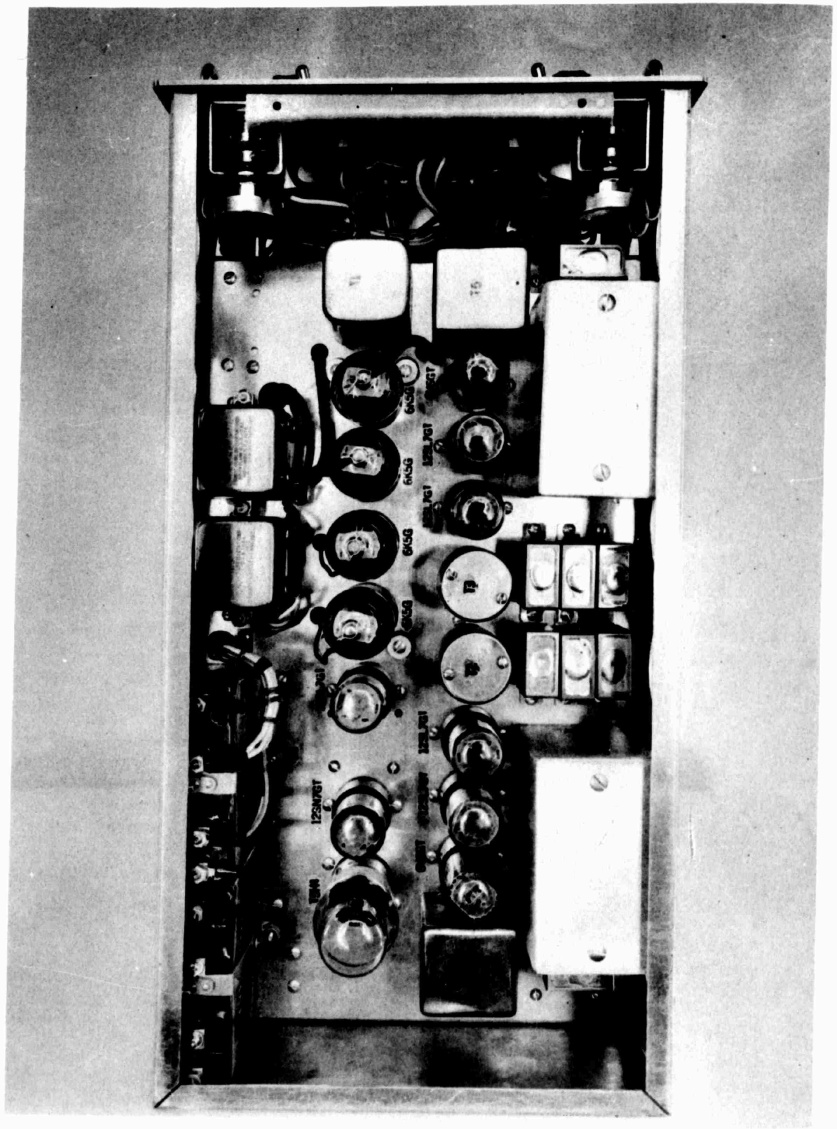
Figures 11, 12, and 13 show the control unit, AM-1/ASQ-1, which contains the detector circuit and the two-channel stabilizer. Electrical connections to this unit are made by means of a plug mounted in the rear of the chassis which engages a socket built into the mounting rack. Figure 14 shows the panel of AM-1/ASQ-1 on which are mounted the balance meter and all operating controls for the AN/ASQ-1 equipment. This localization of controls simplifies installation problems since only this one unit need be within reach of the operator during flight. AM-1/ASQ-1 is 7-7/8 by 10-3/8 by 19-3/4 inches and weighs 29 pounds.

O-1/ASQ-1

The driver unit, O-1/ASQ-1, is shown in Figures 15, 16, and 17. This unit contains the 400-cycle master oscillator, the detector element driver, the stabilizer element driver, the servo-motor field supply, and the electronic voltage regulator. The voltage regulator introduces a considerable power loss but its use is justified by the resulting improvement in overall stability of operation. The regulator makes possible the elimination of all batteries for plate supply. Connections to O-1/ASQ-1 are made by means of a plug mounted in the rear of the chassis. The driver unit is regularly installed with the control unit in a mounting rack but under crowded conditions may be installed wherever desired since this unit has no controls and need not be accessible to the



CONTROL UNIT AM-1/ASQ-1
FIGURE 11



AM-1/ASQ-1 TOP VIEW
FIGURE 12

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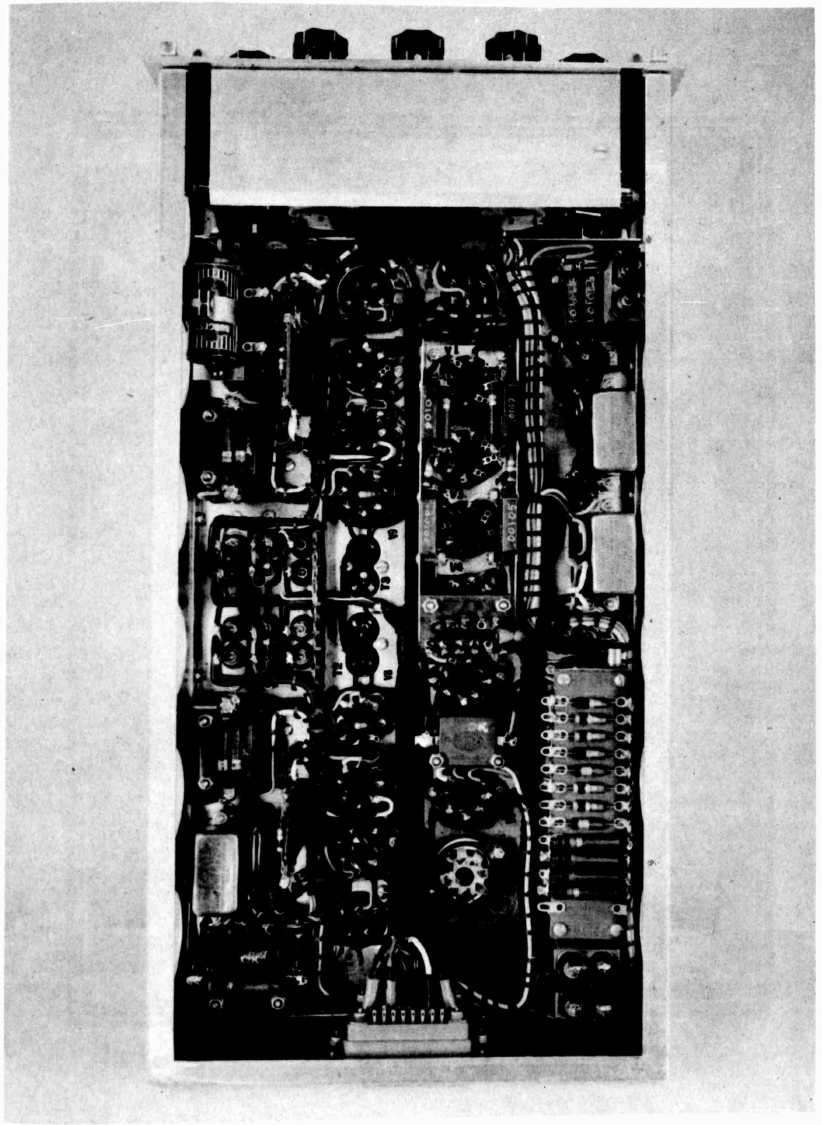
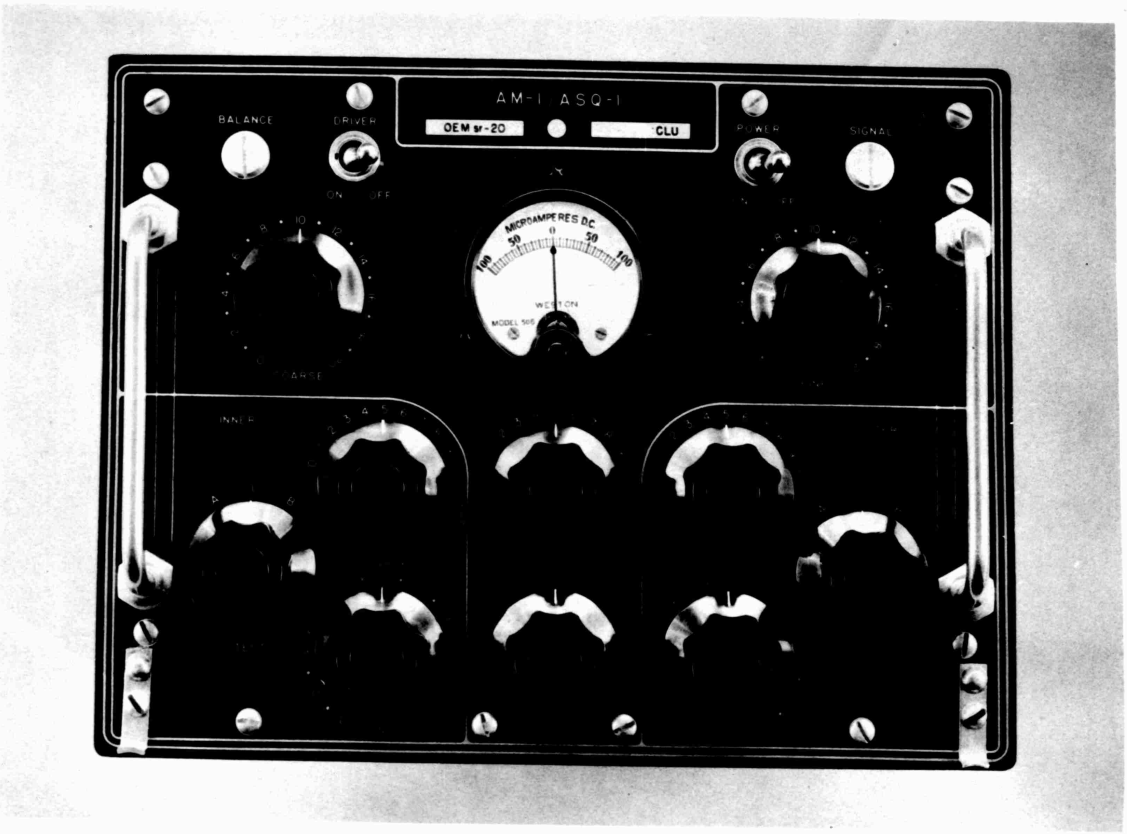
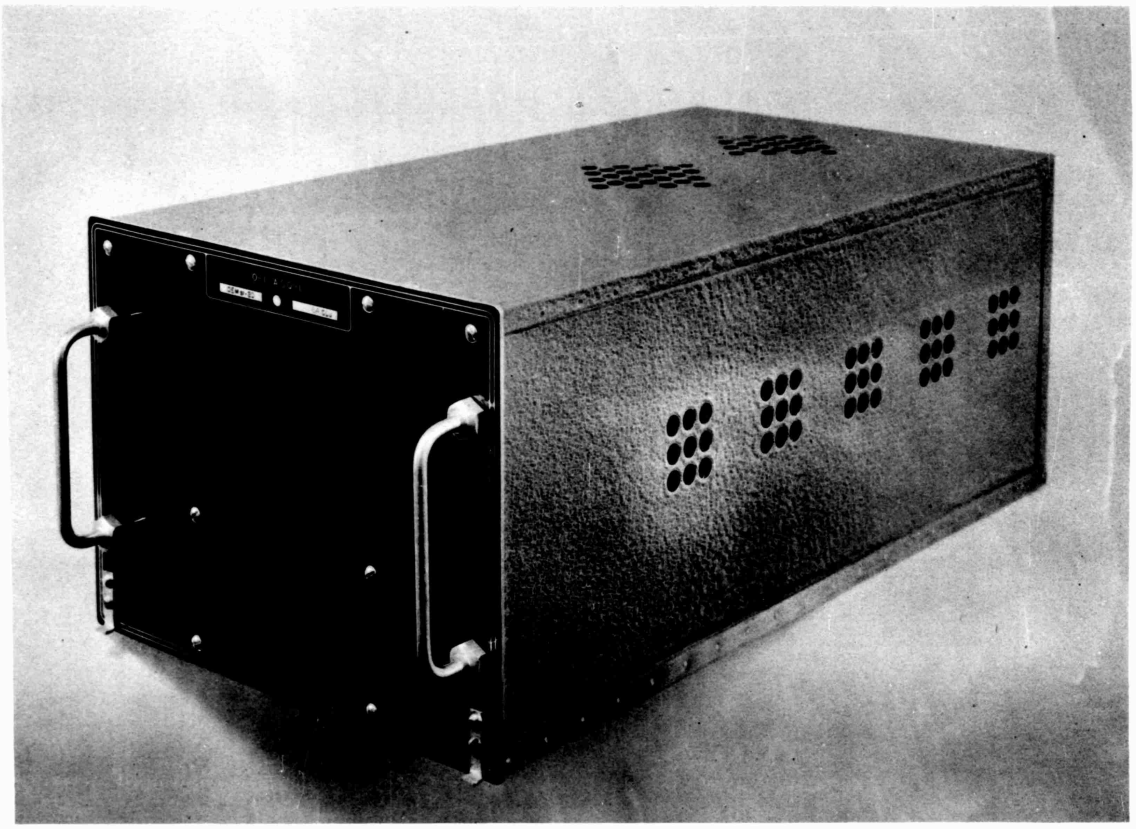


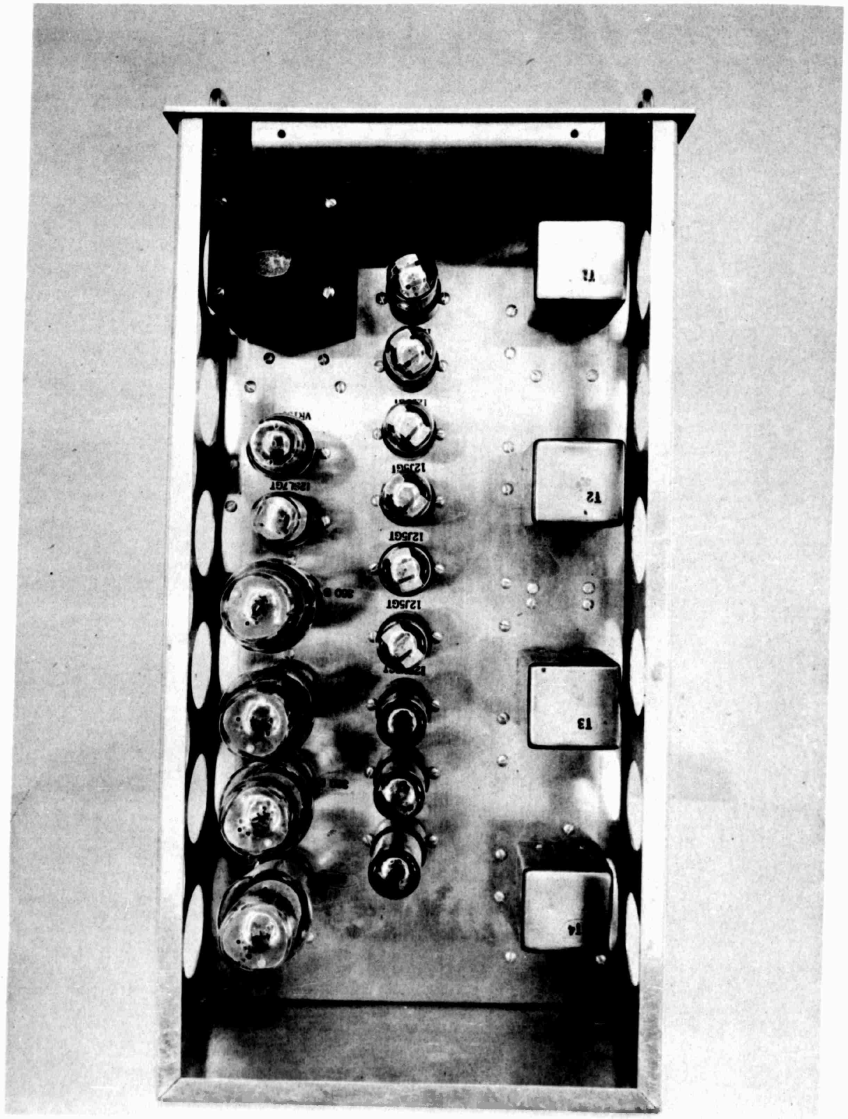
AM-1/ASQ-1 BOTTOM VIEW
FIGURE 13



AM-1/ASQ-1 PANEL
FIGURE 14



DRIVER UNIT O-1/ASQ-1
FIGURE 15



O-1/ASQ-1 TOP VIEW, DUST COVER REMOVED
FIGURE 16

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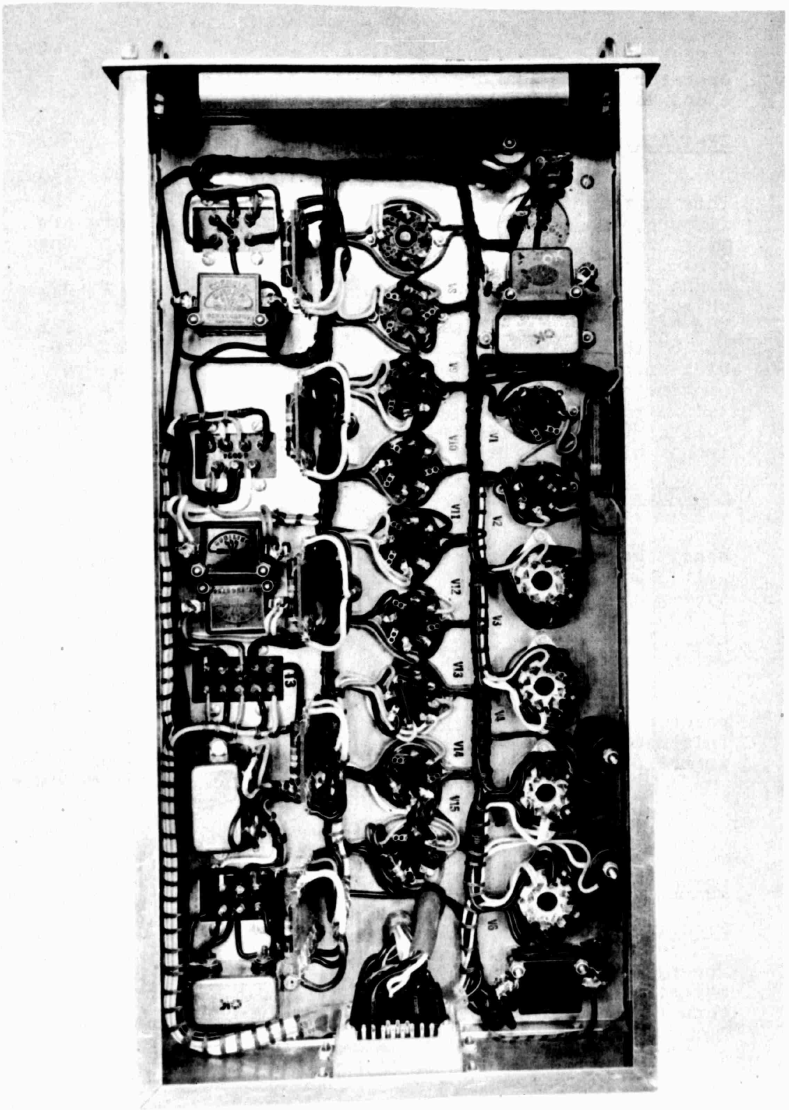


O-1/ASQ-1 BOTTOM VIEW, DUST COVER REMOVED
FIGURE 17

operator during flight. O-1/ASQ-1 has the same dimensions as AM-1/ASQ-1 and weighs 19 pounds.

DY-4/ASQ-1

Figures 18 and 19 show the power unit, DY-4/ASQ-1. This unit contains the dynamotor (Eicor ML. 4120-50), the filters, the input closing relay, and fuses. Filters are provided in both the input and the output circuits of the dynamotor to suppress high-frequency disturbances which might interfere with radio operation. The closing relay, which closes the battery supply circuit, is operated by the "power" switch on the panel of the control unit. The use of this relay makes unnecessary the extension of the high-current conductors to the control unit. Fuses are provided in the low-voltage power supply circuit, in the vacuum tube heater circuit, and in the high-voltage circuit of the dynamotor. The power unit is 12 by 5 by 7-3/8 inches high and weighs 12 pounds.

RECORDER

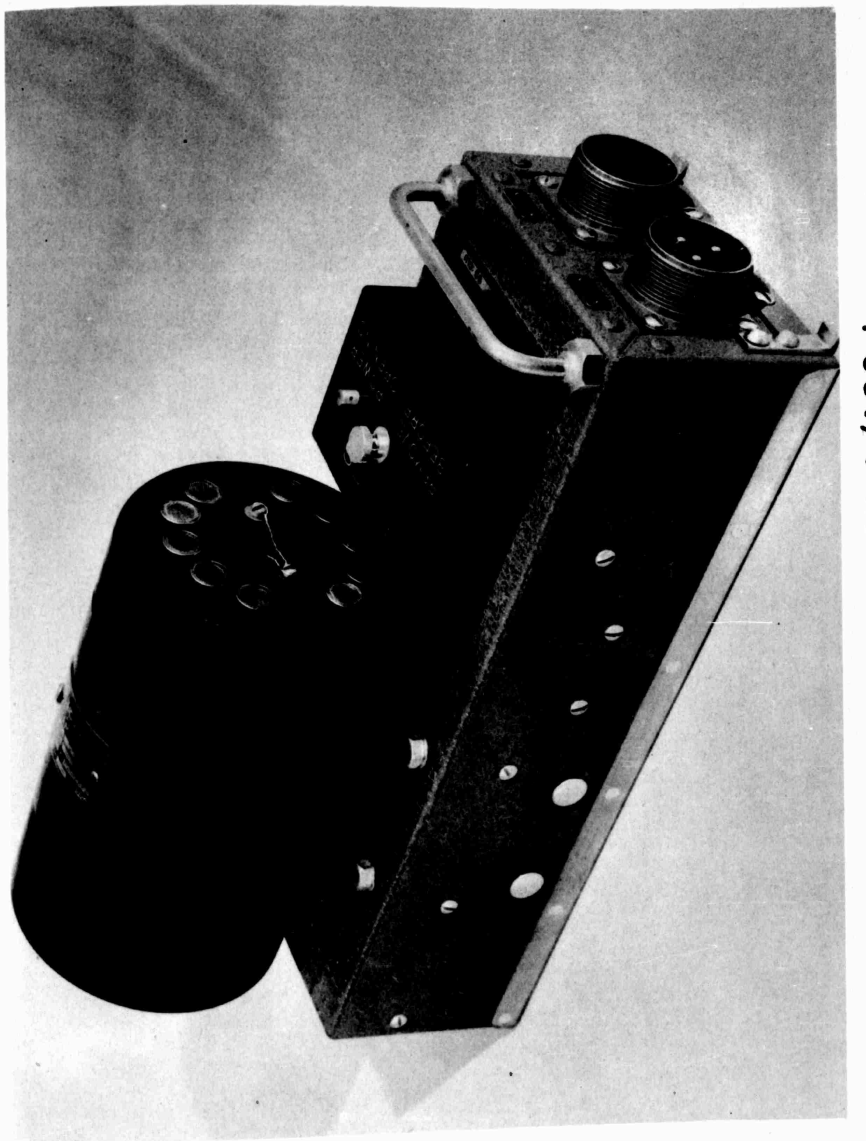
The ink-writing recorder (Esterline-Angus Supersensitive Recorder) is shown in Figure 20. The recorder writes a continuous record of the output of the detector system on a six-inch-wide paper tape. The paper speed is adjustable but as generally used is 3 inches per minute. The recorder is 8-5/8 by 8-3/4 by 13-1/4 inches and weighs 35 pounds.

There is under development a very much smaller recorder which will weigh about 6 pounds. When available, this new recorder will be very convenient, especially for installations in small airplanes.

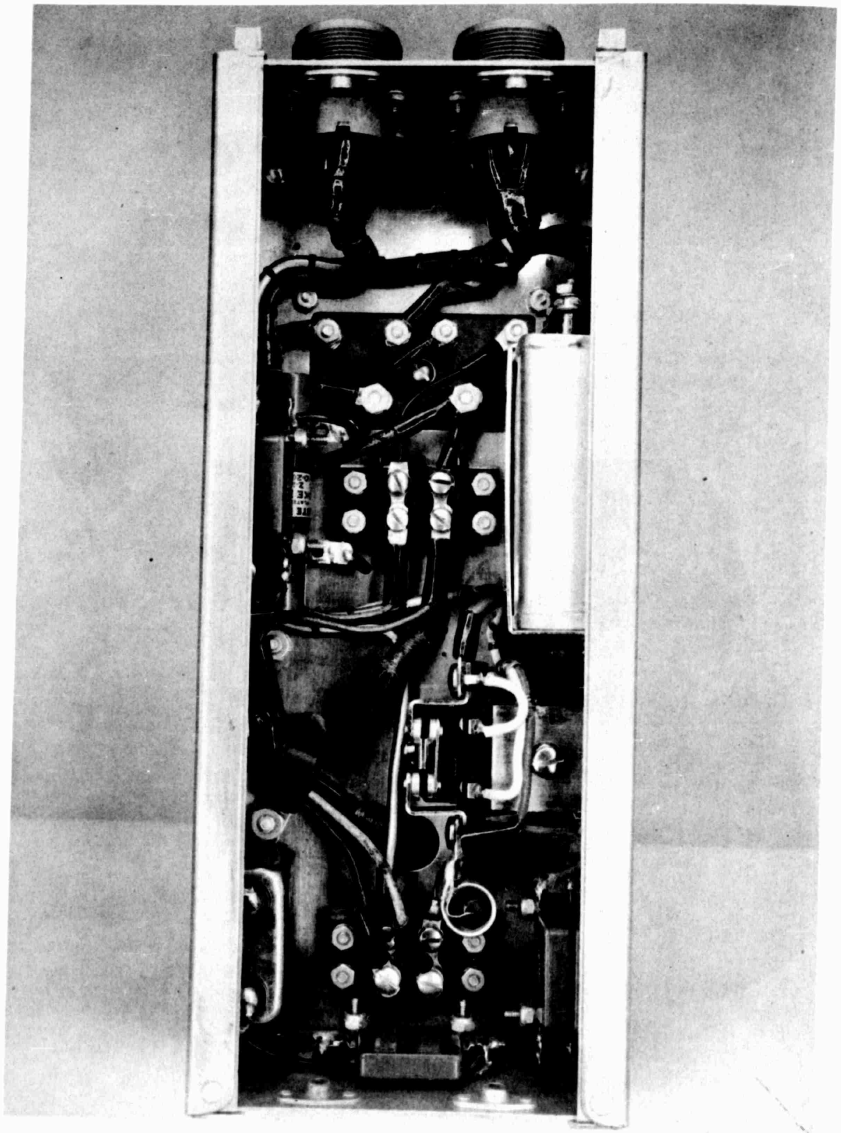
PERFORMANCE CHARACTERISTICS

DETECTOR SYSTEM

Frequency Response The performance of the detector system depends upon its response-frequency characteristic. The system should discriminate against the low frequency magnetic noise accompanying airplane maneuvers and at the same time transmit submarine signals without excessive



POWER UNIT DY-4/ASQ-1
FIGURE 18



DY-4/ASQ-1 BOTTOM VIEW
FIGURE 19

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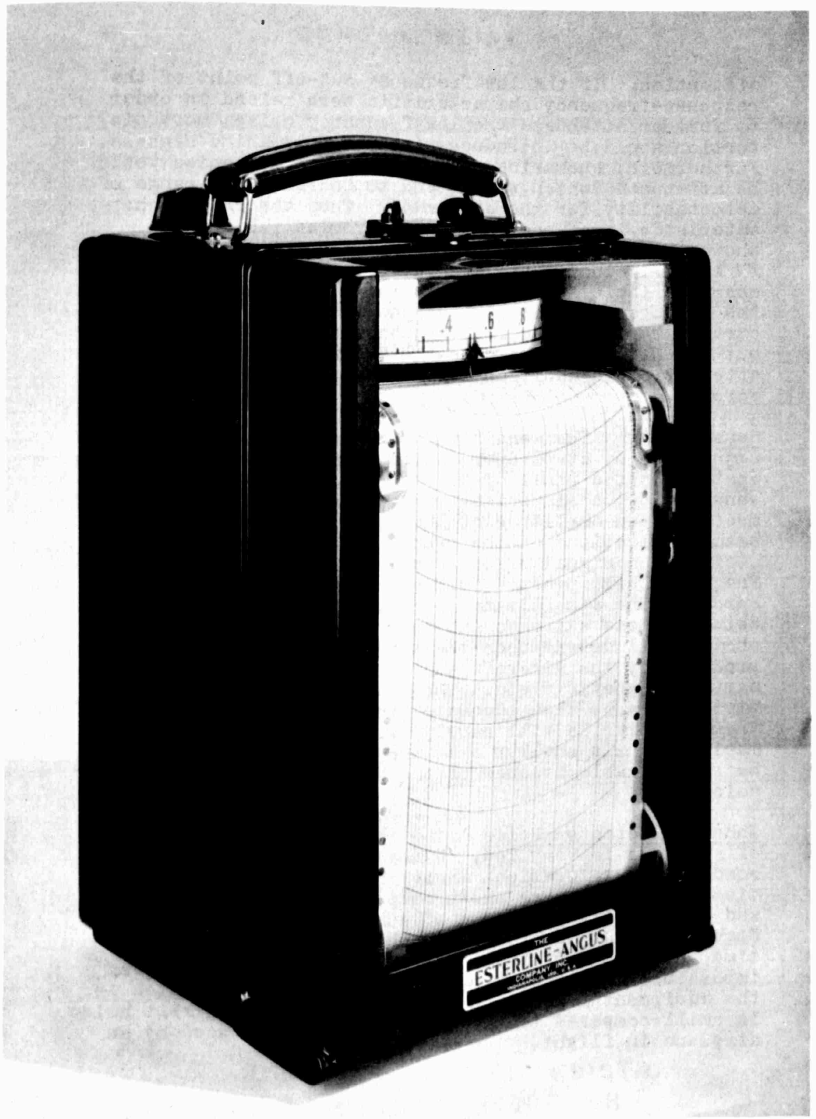

ESTERLINE-ANGUS RECORDER
FIGURE 20

distortion. If the low-frequency cut-off point of the response-frequency characteristic were raised in order to further attenuate the low-frequency noise, more distortion would be introduced into the submarine signals. Furthermore, submarine signals at large distances would be attenuated which would tend to decrease the range of detectability for the equipment. Thus the chosen characteristic is of necessity a compromise. Figure 21 shows the response-frequency characteristic of the AN/ASQ-1 including the recorder, and Figure 22 shows the characteristic as determined from the voltage output of the detector circuit without the recorder. The two curves are identical for frequencies below 0.4 cycles but for higher frequencies the recorder introduces attenuation in addition to that caused by the detector circuit.

Sensitivity The sensitivity of the detector system is adjustable by steps over a wide range by means of a control on the panel of the control unit. At the lowest sensitivity, a sinusoidal magnetic signal at 0.3 cycles must have an amplitude of 125 gammas to produce full-scale deflections on the recorder. At the highest sensitivity, a signal of one gamma amplitude at the same frequency will produce full-scale deflections on the recorder. The sensitivity normally used is intermediate between these extremes and in a particular case the choice will depend upon the level of the magnetic noise produced by the aircraft and by the variations in the earth's magnetic field. The available range of sensitivity is more than adequate since the signal received from a submarine will rarely exceed 100 gammas and submarine signals smaller than one gamma will probably not be recognizable because of the background of magnetic noise.

Inherent Detector Noise of AN/ASQ-1 is very low. The inherent background noise conditions at locations where the magnetic field variations are small have shown output levels between 0.05 and 0.2 gammas. A record of such a test is shown in Figure 23. At least part of this output is caused by time variations of the earth's magnetic field. It is impossible to say what part of the output originates in the equipment itself, but at any rate, the inherent noise is small compared to the magnetic noise produced by an airplane in flight.

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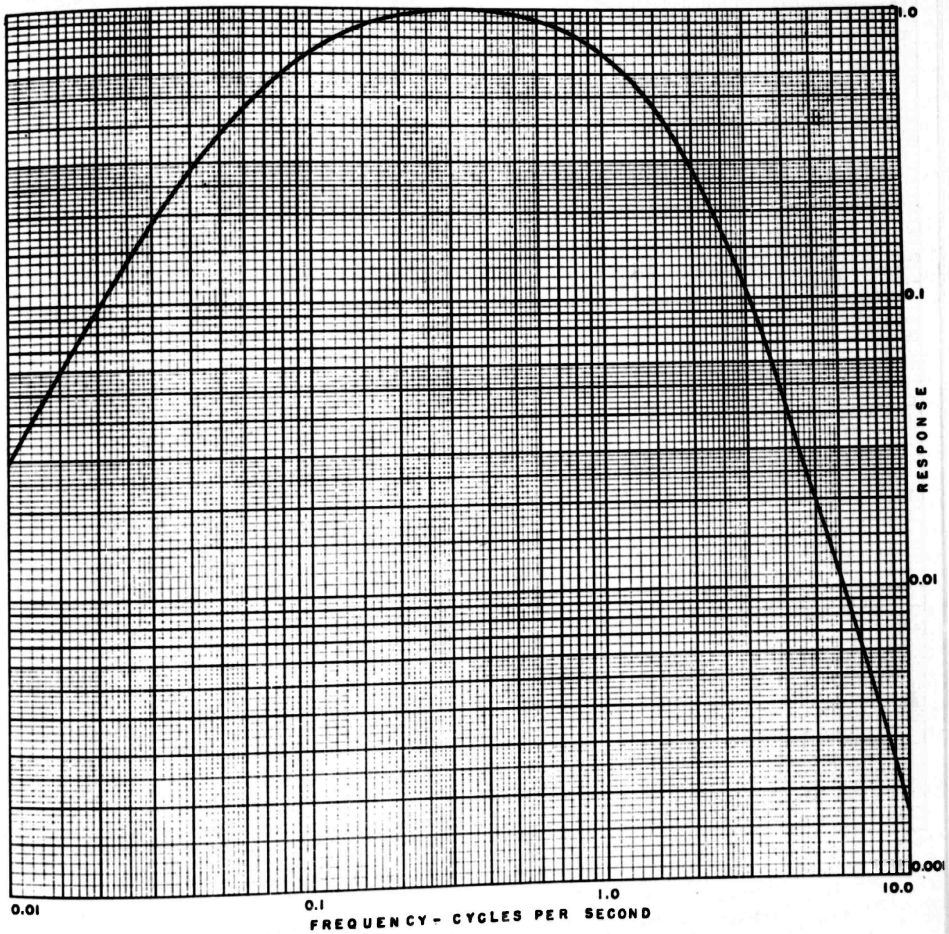
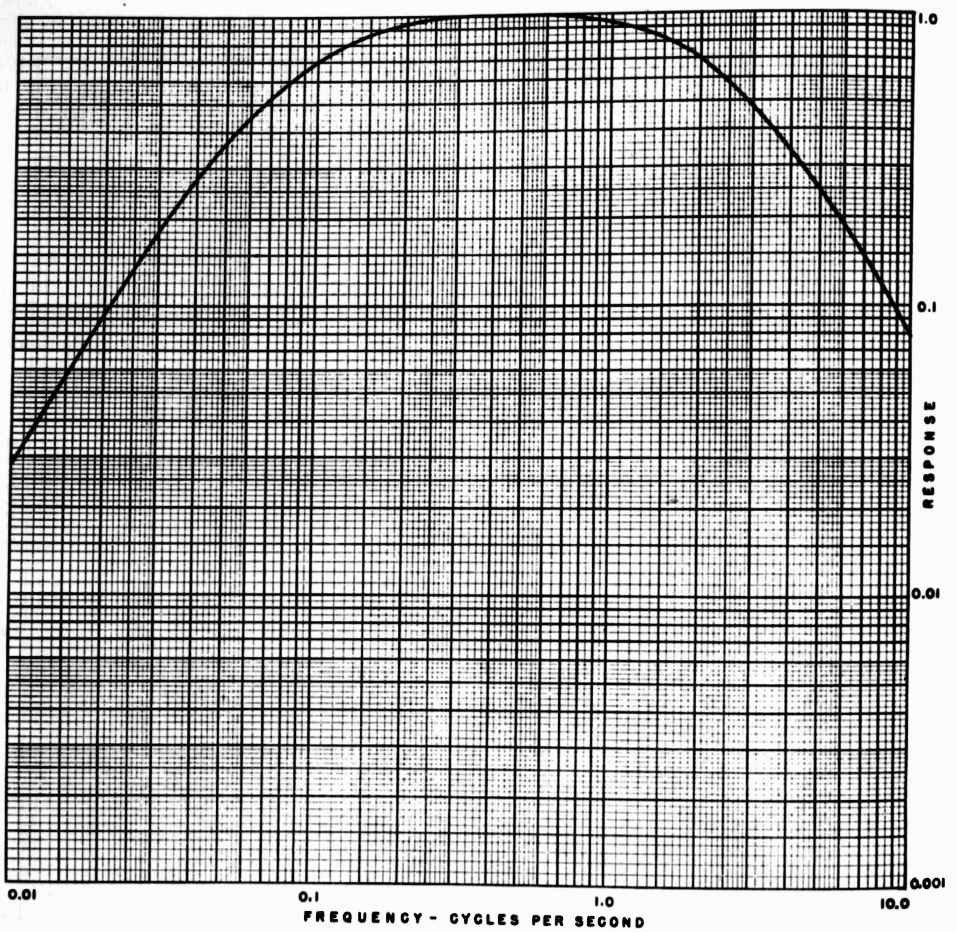


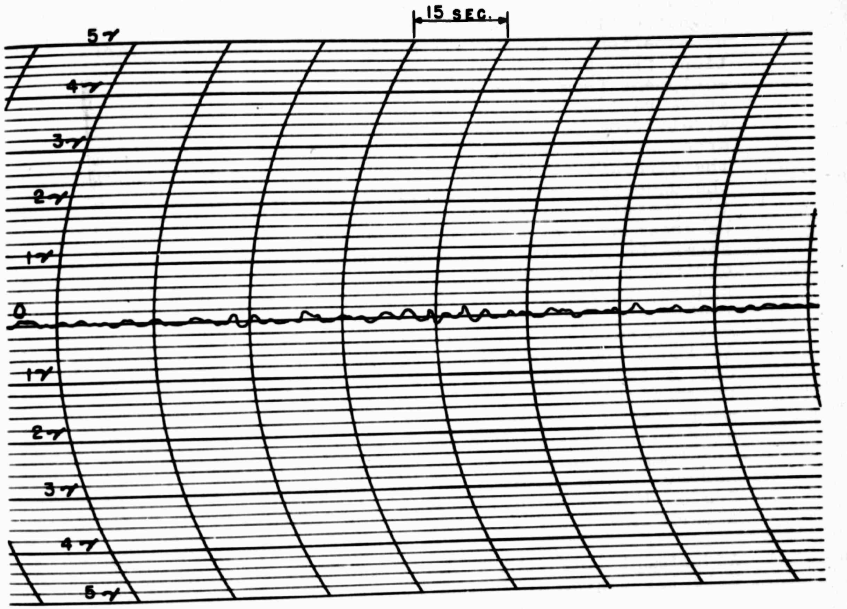
RESPONSE-FREQUENCY CHARACTERISTIC OF AN/ASQ-1 INCLUDING RECORDER

FIGURE 21



RESPONSE-FREQUENCY CHARACTERISTIC
OF AN/ASQ-1 EXCLUSIVE OF RECORDER

FIGURE 22



TEST RECORD MADE UNDER
MAGNETICALLY QUIET CONDITIONS

FIGURE 23

Noise Level in Flight The background of magnetic noise recorded in flight arises from variations in the earth's magnetic field and from magnetic fields associated with the aircraft. The noise due to variations in the earth's magnetic field arises not only from variations with time, as experienced at any given point, but also from variations from point to point as the aircraft carries the equipment from place to place. This point-to-point, or space variation in the earth's magnetic field differs widely from region to region but is usually small over areas of deep ocean. The magnetic noise arising from the aircraft itself depends upon the precision with which the undesired magnetic fields have been compensated at the position of the detector element. This noise will be greatest during maneuvers of the aircraft. Figure 24 shows the magnetic background noise recorded by AN/ASQ-1 equipment during straight and level flight of a PBY airplane. On the record, time progresses from left to right, and the interval between lines is 30 seconds. The maximum amplitude of the record during the interval shown is about one-fourth gamma so that a submarine signal of one or two gammas amplitude would be detectable. Figure 25 shows the noise level recorded by the AN/ASQ-1 equipment during straight and level flight of a Grumman G 21-A airplane. The maximum amplitude of the noise is less than one-fourth gamma. The noise recorded during rapid maneuvers of an aircraft may be considerably larger, depending on the uncompensated magnetic fields of the particular aircraft.

Adjustment in Flight The only adjustment made on the detector system in flight is that of magnetic balance of the detector element. The deviation of the magnetic state of the detector from perfect magnetic balance is indicated continuously by the balance meter on the panel of the control unit. Since this deviation depends upon the magnitude of the earth's magnetic field, readjustment will be necessary if the aircraft travels to a new area where the earth's field has a markedly different value. The sensitivity of the detector system depends upon the deviation from perfect balance so the permissible deviation is determined by the constancy of sensitivity demanded. Figure 26 shows the relation between detector sensitivity and the deviation of the detector element from perfect magnetic balance. If a decrease of 20 percent in sensitivity is allowable, then an increase or decrease of 1000 gammas in the earth's field can occur before readjustment is necessary.

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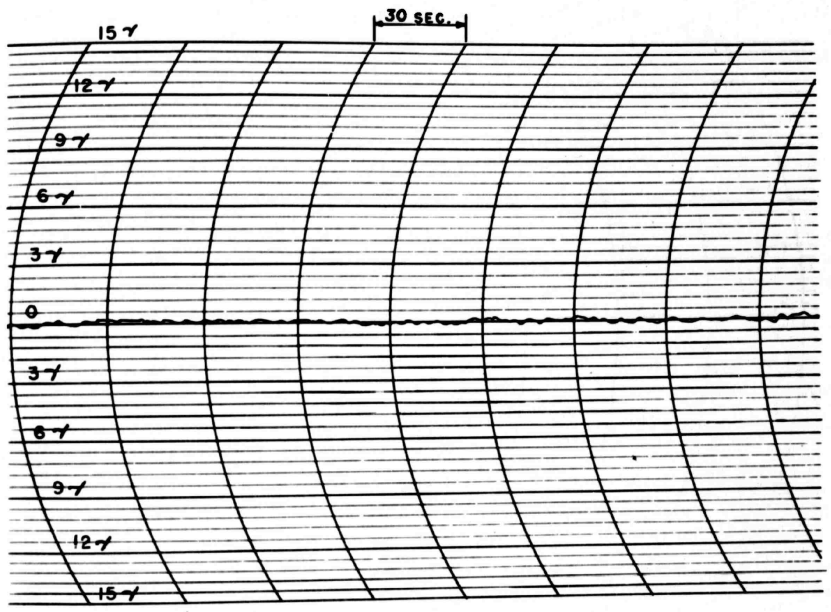
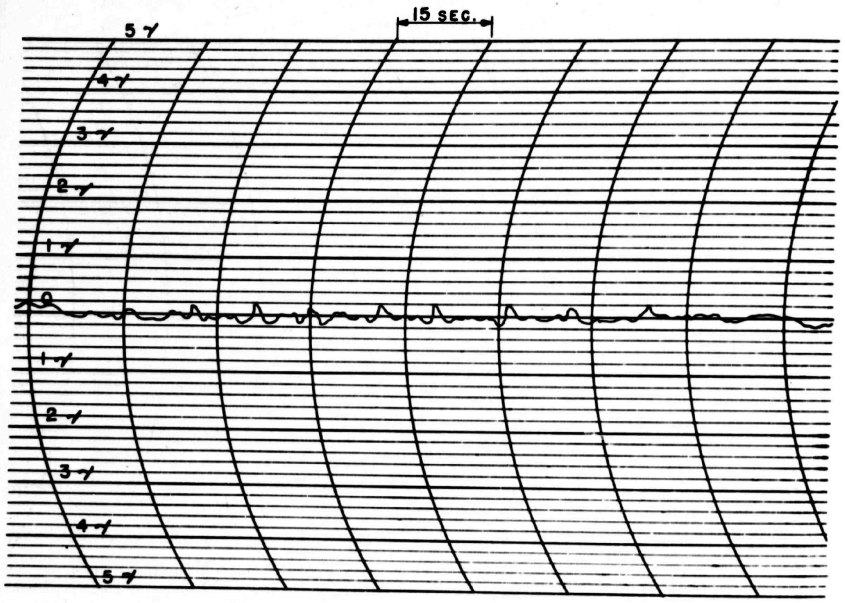


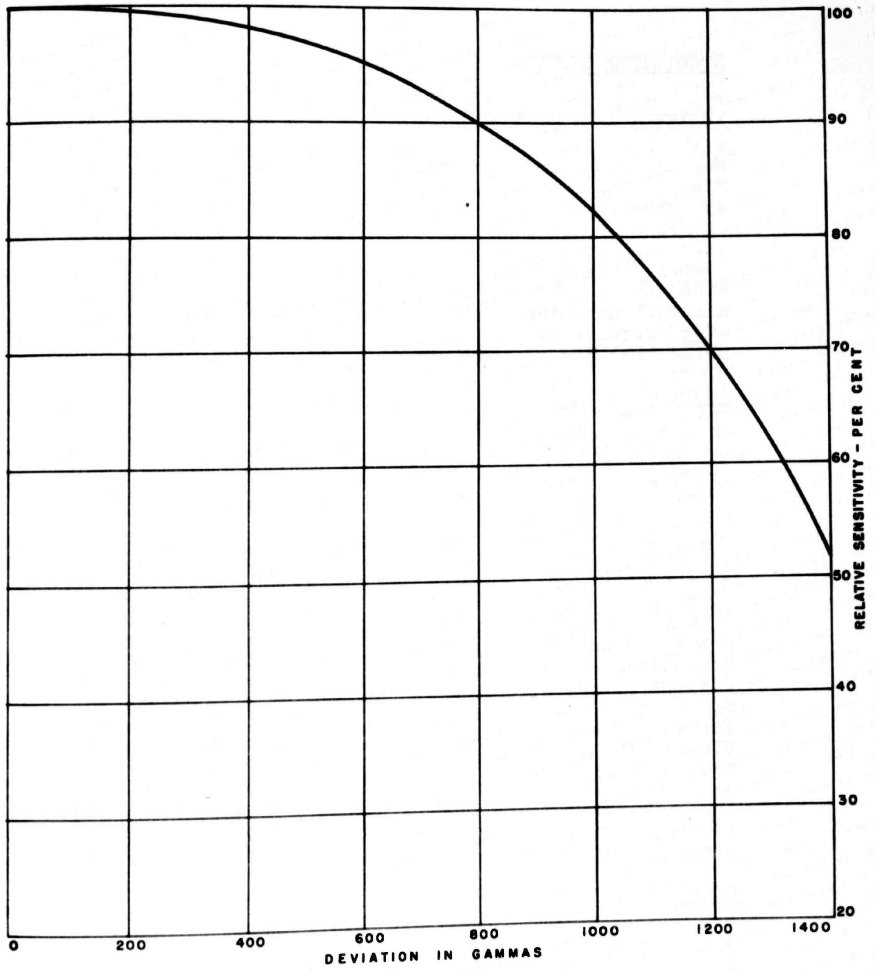
BACKGROUND OF MAGNETIC NOISE RECORDED DURING STRAIGHT AND LEVEL FLIGHT OF A PBY AIRPLANE

FIGURE 24



BACKGROUND OF MAGNETIC NOISE
RECORDED DURING STRAIGHT AND
LEVEL FLIGHT OF A G-21A AIRPLANE

FIGURE 25



EFFECT OF DEVIATIONS FROM EXACT
MAGNETIC BALANCE ON DETECTOR SENSITIVITY

FIGURE 26

STABILIZER SYSTEM

Precision of Operation The overall performance of the AN/ASQ-1 equipment is closely related to the precision with which the stabilizer system keeps the detector element oriented in the direction of the earth's magnetic field. The maximum stabilizer error of AN/ASQ-1 during expected aircraft maneuvers is only about five minutes of arc. An error of this magnitude will cause a spurious signal of less than 0.1 gammas which is smaller in general than the effects produced by disturbances outside the equipment. The magnetic noise recorded during aircraft maneuvers which arises from magnetization and eddy currents will establish a higher threshold of noise than can be attributed to stabilizer errors.

Adjustment in Flight The stabilizer system accurately maintains the detector element in the particular direction to which it is adjusted relative to the direction of the earth's magnetic field. During flight the stabilizer system must be initially oriented so that this preferred direction coincides with the direction of the earth's magnetic field. This adjustment does not depend upon the direction or magnitude of the earth's magnetic field and the need for readjustment arises only because of the drift of circuit constants with time as caused by temperature changes, supply voltage variations, aging of tubes, etc. In the AN/ASQ-1, these effects have been greatly reduced by the careful choice of circuit components and good circuit design. Under reasonable conditions of operation, the adjustment of orientation will be required about twice a day. While means are provided for accurately checking the orientation of the detector element while in flight, no provision has been made for continuous indication of the drift from proper adjustment. However, the character of the record produced by the detector system under the condition of misadjustment is such that the average operator could be expected to realize the need for readjustment.

SERVICEABILITY

Reliability of operation is a most important consideration in the design and manufacture of equipment to be used under conditions of varying supply voltage, variable temperature, severe vibrations, and high humidity.

The AN/ASQ-1 operates equally well with supply voltages from 22 to 29 volts and the output is practically unaffected by sudden changes of supply voltage within this range.

The equipment is designed and tested for operation at temperatures between -20°F and 140°F. The only effect of large temperature changes within this range is a small change in detector sensitivity which is not a serious defect since the sensitivity is readily adjustable over a wide range by means of a control on the panel of AM-1/ASQ-1. Circuit components are selected, processed, and tested for stability under varying temperatures.

Stringent requirements on design and construction are imposed by the severe vibration conditions under which the equipment is used. The equipment is mechanically rugged, and adequate shock mounting is provided. The electronic circuits are designed for low microphonic effects, and each unit of AN/ASQ-1 is tested for satisfactory operation while being subjected to violent vibration on a shaking table.

In the design, construction, and testing of the AN/ASQ-1 equipment, adequate consideration has been given to the problem of operation under conditions of high humidity. Long-term stability and reliability have been achieved through the use of high-quality components, careful choice of insulating materials, and thorough impregnation of components.

With the background of experience in the design, production, and operation of the Mark IV-B2 MAD system, it has been possible to select components and to set up a quality-control procedure which justifies the belief that the AN/ASQ-1 equipment will be subject to relatively little trouble from failures of components, even under extremely adverse conditions of moisture or temperature.

INSTALLATION

AN/ASQ-1 represents an advance over the Mark IV-B2 equipment in regard to its ease of installation. The reduced size and weight allow AN/ASQ-1 to be used in smaller airplanes than could accomodate the previous model. In larger airplanes installation is more convenient not only because of the reduced size and weight but also because a single unit carries all the controls. The weight of the separate units of an AN/ASQ-1 installation,

together with typical accessories, are listed in Table I. The control unit and the driver unit are usually mounted one above the other in the same rack if such installation is convenient. Interconnections between the units are made in a junction box which is regularly built into the rack in which the driver unit and control unit are mounted but which may be installed in any convenient location. The streamlined housing containing the DT-1/ASQ-1 unit is usually attached to the outside of the aircraft so as to be accessible for inspection and not to occupy valuable space inside the aircraft. One example of the installation of the housing is shown in Figure 27. In this case, the housing was attached to the end of the wing by means of a fairing. This is a convenient method of mounting in many cases and the housing in this position does not alter the control characteristics of the airplane. Another example of the installation of the housing is given in Figure 28 which shows the attachment to a PBM airplane. Figure 29 shows still another installation of the DT-1/ASQ-1 unit. In this case, it is in a special tail extension attached to a PBY airplane.

OS2U

One of the small airplanes in which AN/ASQ-1 equipment has been installed is the Vought-Sikorsky OS2U-3 land plane. Figure 30 shows the streamlined housing for the DT-1/ASQ-1 unit mounted on the upper surface of the right wingtip. The housing does not appreciably alter the flight characteristics of the airplane. Figure 31 shows the O-1/ASQ-1 unit installed behind the pilot's seat. The AM-1/ASQ-1 unit is installed as shown in Figure 32 behind the observer's seat. The operation of the AN/ASQ-1 equipment in this experimental installation was completely satisfactory even during maneuvers much more rapid than those which could be executed by a larger airplane.

TBF

An experimental AN/ASQ-1 installation has been made in a Grumman TBF-1 airplane. Figure 33 shows a side view of the airplane with wings partially folded. The streamlined housing for DT-1/ASQ-1 is seen built into the end of the wing. Figure 34 shows the streamlined housing as viewed from the under side of the wing. The units accessible to the operator are shown in Figure 35. The control unit is installed on the right side of the upper shelf and the recorder is mounted below it. The other two items

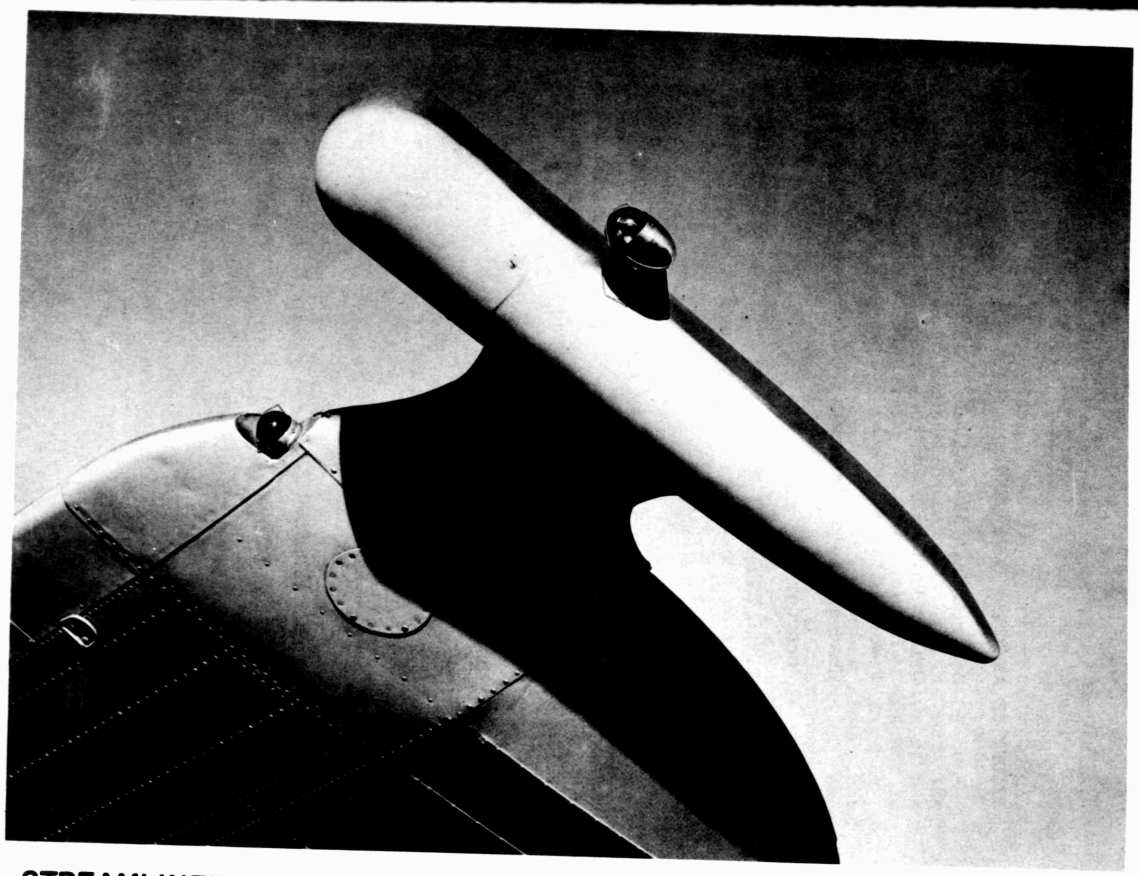
TABLE I

WEIGHT OF AN/ASQ-1 EQUIPMENT:

Control Unit AM-1/ASQ-1	29 Pounds
Driver Unit O-1/ASQ-1	19 "
Power Unit DY-4/ASQ-1	12 "
Head and Motor Assembly DT-1/ASQ-1	5 "
Recorder	35 "
TOTAL EQUIPMENT WEIGHT	100 Pounds

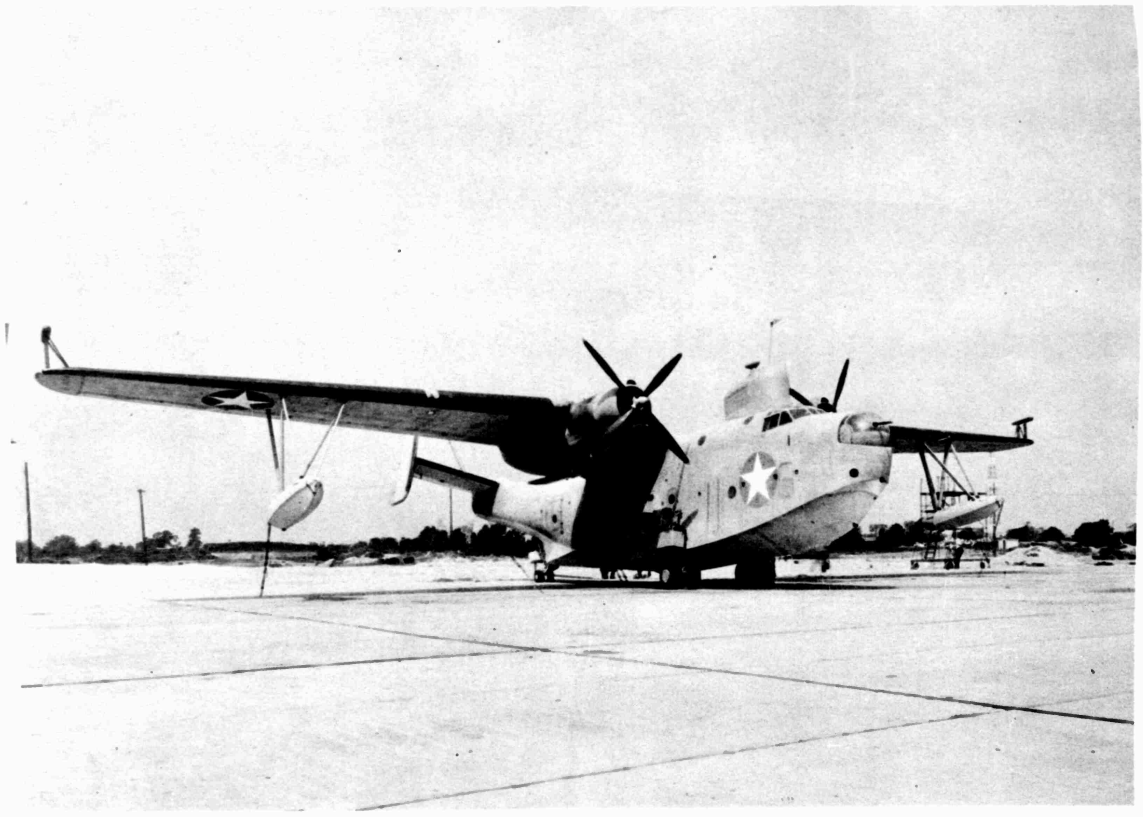
ADDITIONAL WEIGHTS WHICH WOULD BE ADDED IN A TYPICAL INSTALLATION:

Streamlined Housing	4 Pounds
Mounting Rack	13 "
Battery Cable (10 Feet)	2 "
Power Cable (10 Feet)	2 "
Head Cable (50 Feet)	11 "
Remote Signal Meter with 25 Foot Cable	3 "
TOTAL ACCESSORIES	35 Pounds
Plus Equipment (Above)	100 "
TOTAL INSTALLED WEIGHT	135 Pounds



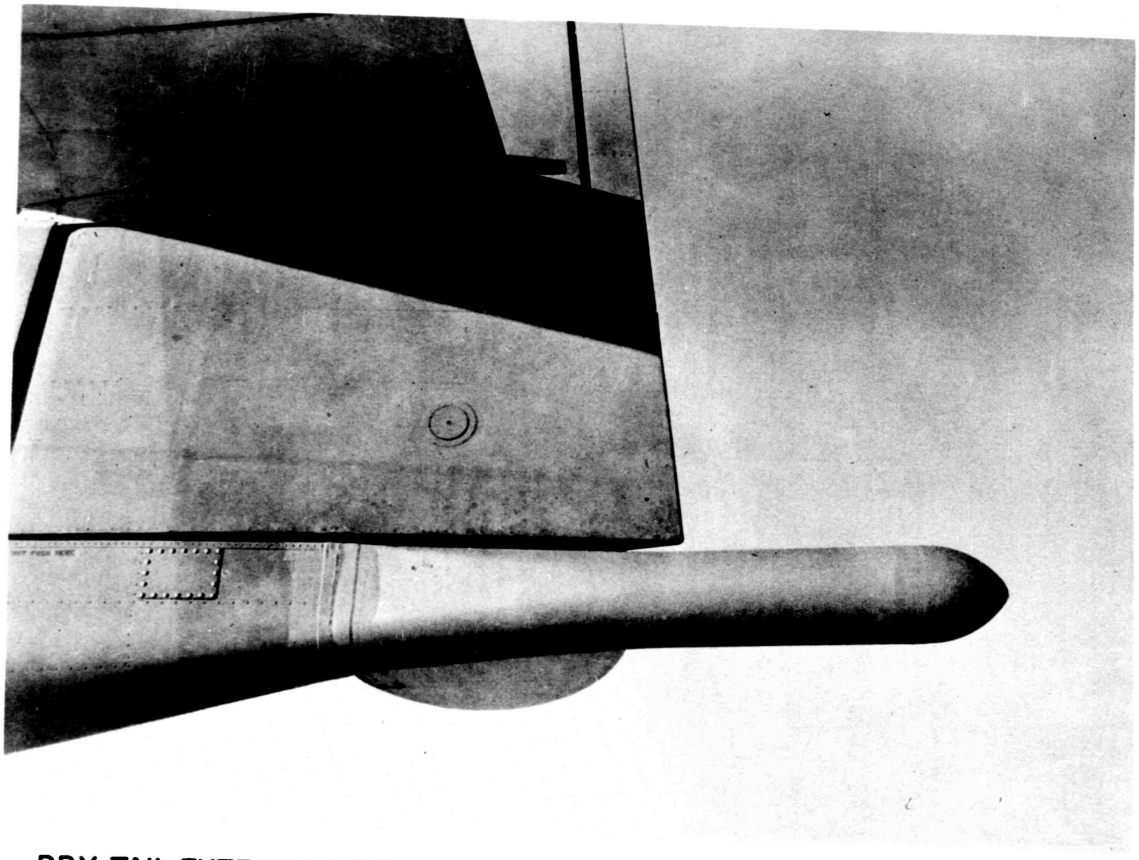
STREAMLINED HOUSING ATTACHED TO WINGTIP BY MEANS OF A FAIRING

FIGURE 27



STREAMLINED HOUSINGS MOUNTED ABOVE WINGTIPS OF A PBM AIRPLANE

FIGURE 28



PBY TAIL EXTENSION FOR MAGNETOMETER HEAD AND MOTOR ASSEMBLY

FIGURE 29

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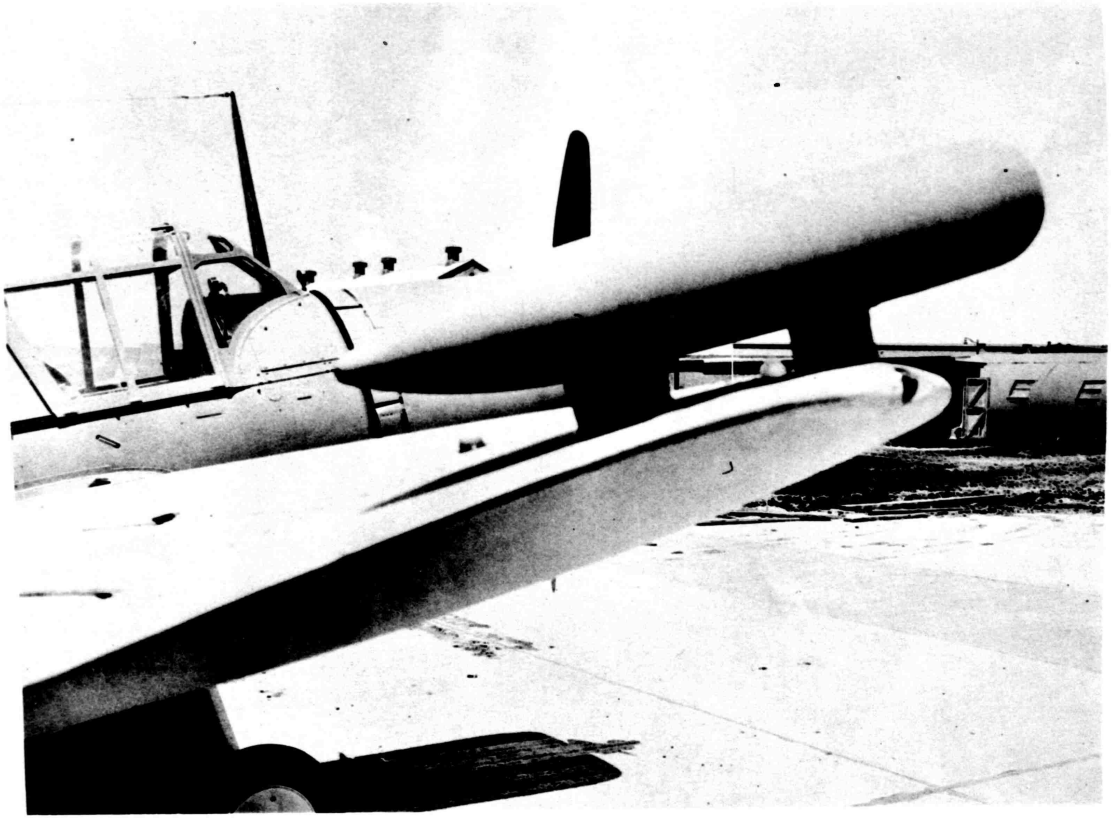
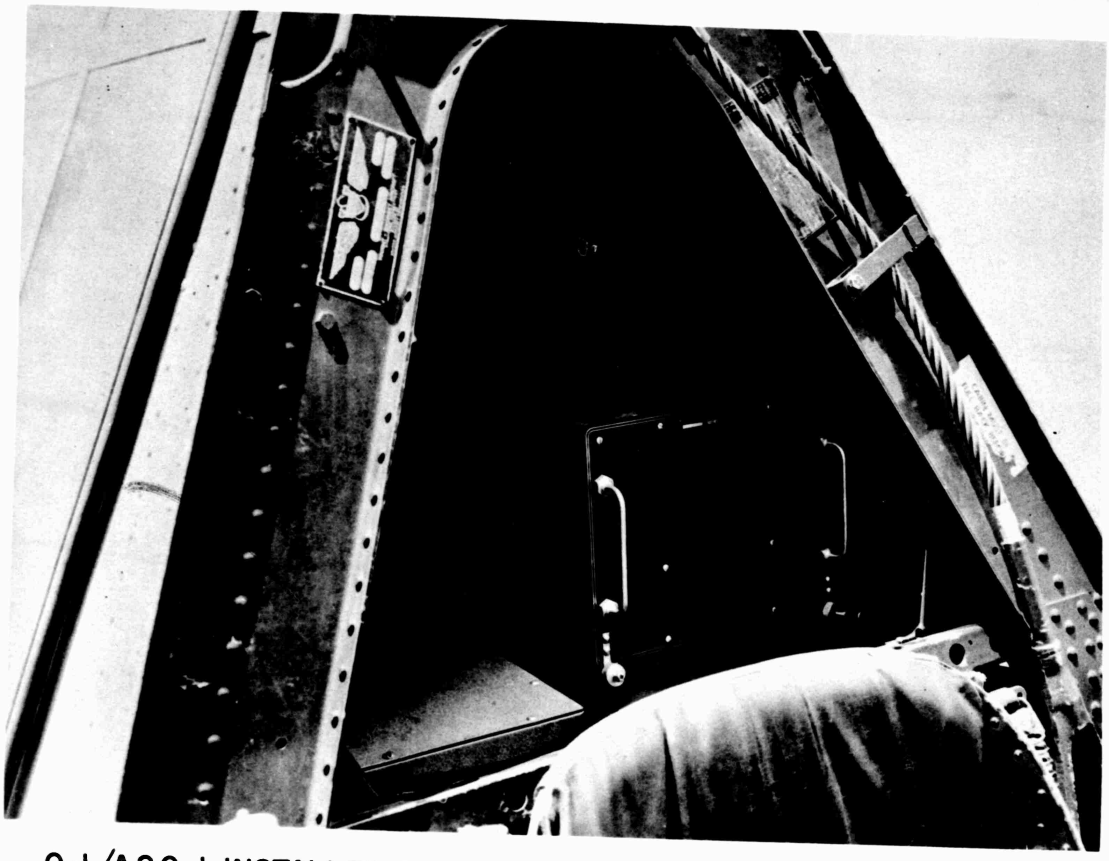


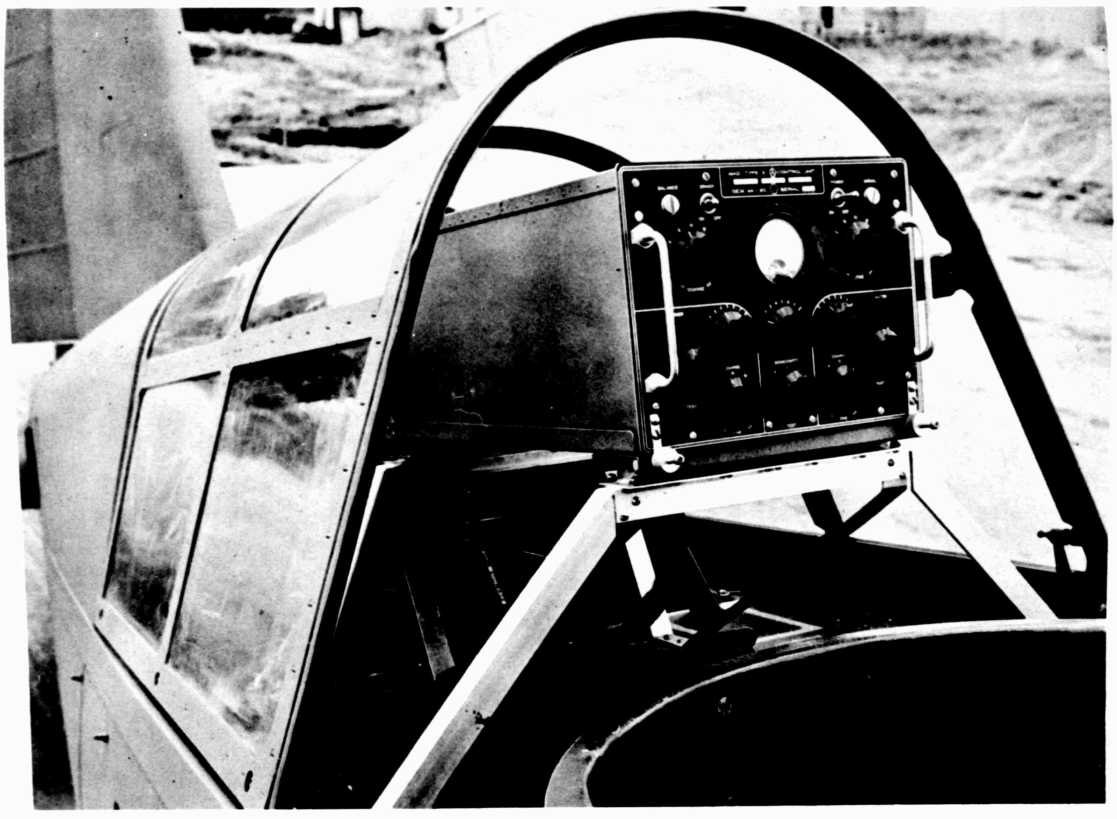
STREAMLINED HOUSING MOUNTED ON THE WING OF AN OS2U AIRPLANE

FIGURE 30



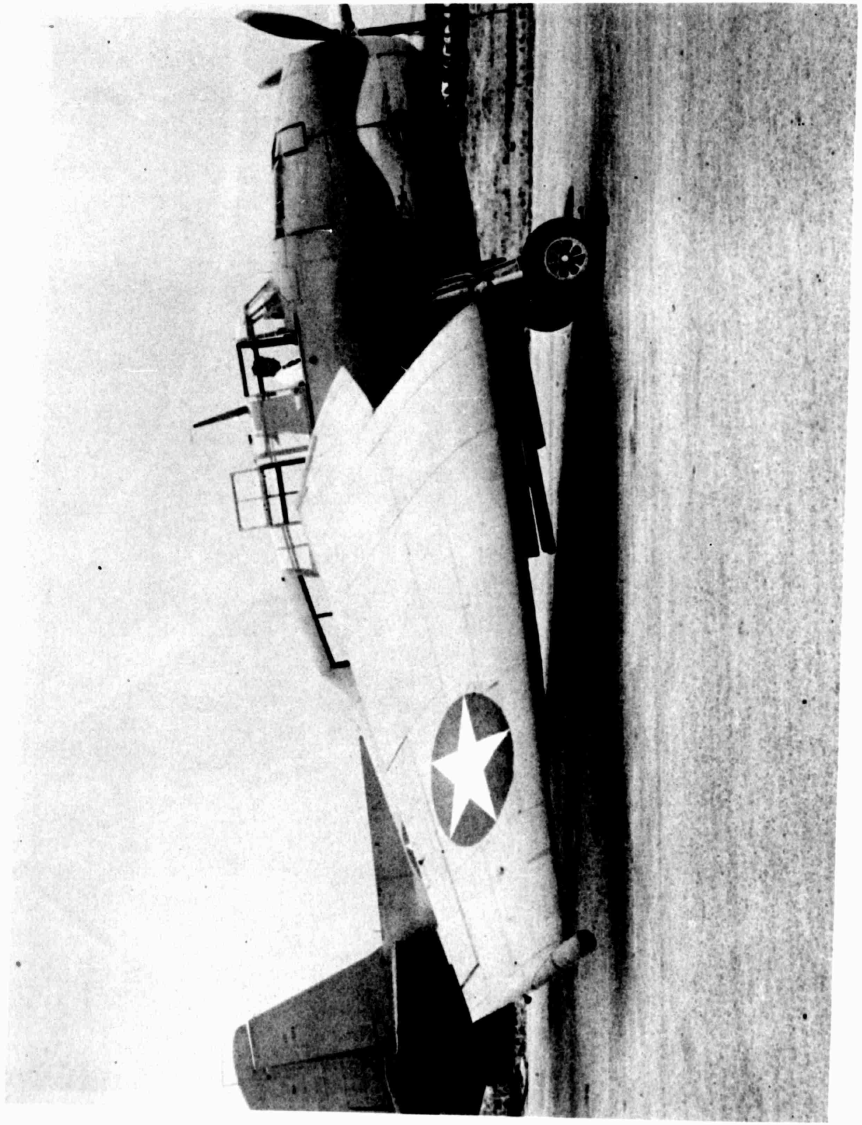
O-1/ASQ-1 INSTALLED BEHIND PILOT'S SEAT IN AN OS2U AIRPLANE

FIGURE 31

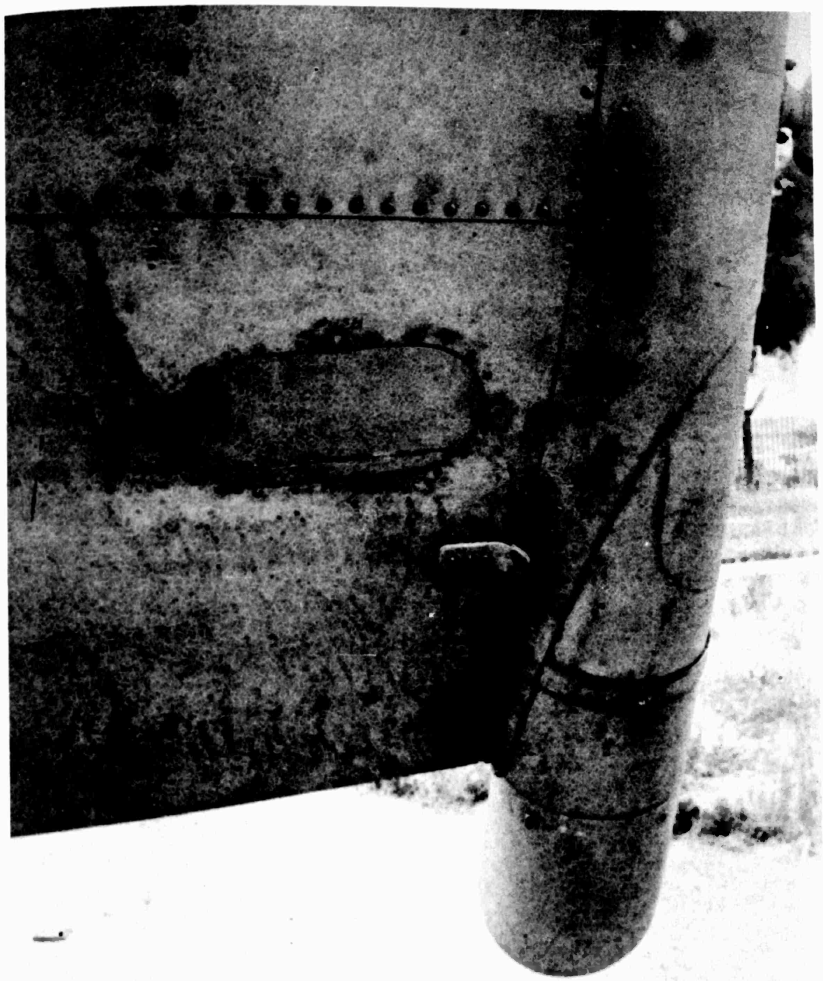


AM-1/ASQ-1 INSTALLED BEHIND OBSERVER'S SEAT IN AN OS2U AIRPLANE

FIGURE 32



TBF-1 AIRPLANE EQUIPPED WITH AN/ASQ-1
FIGURE 33



STREAMLINED HOUSING BUILT INTO WINGTIP
OF TBF-1 AIRPLANE
FIGURE 34

of equipment shown in Figure 35 are not units of AN/ASQ-1. The driver unit, O-1/ASQ-1, shown in Figure 36, is mounted behind the observer's seat. In Figure 37, the pilot's signal meter is shown mounted above the instrument panel. The operation of the AN/ASQ-1 equipment in this installation was entirely satisfactory.

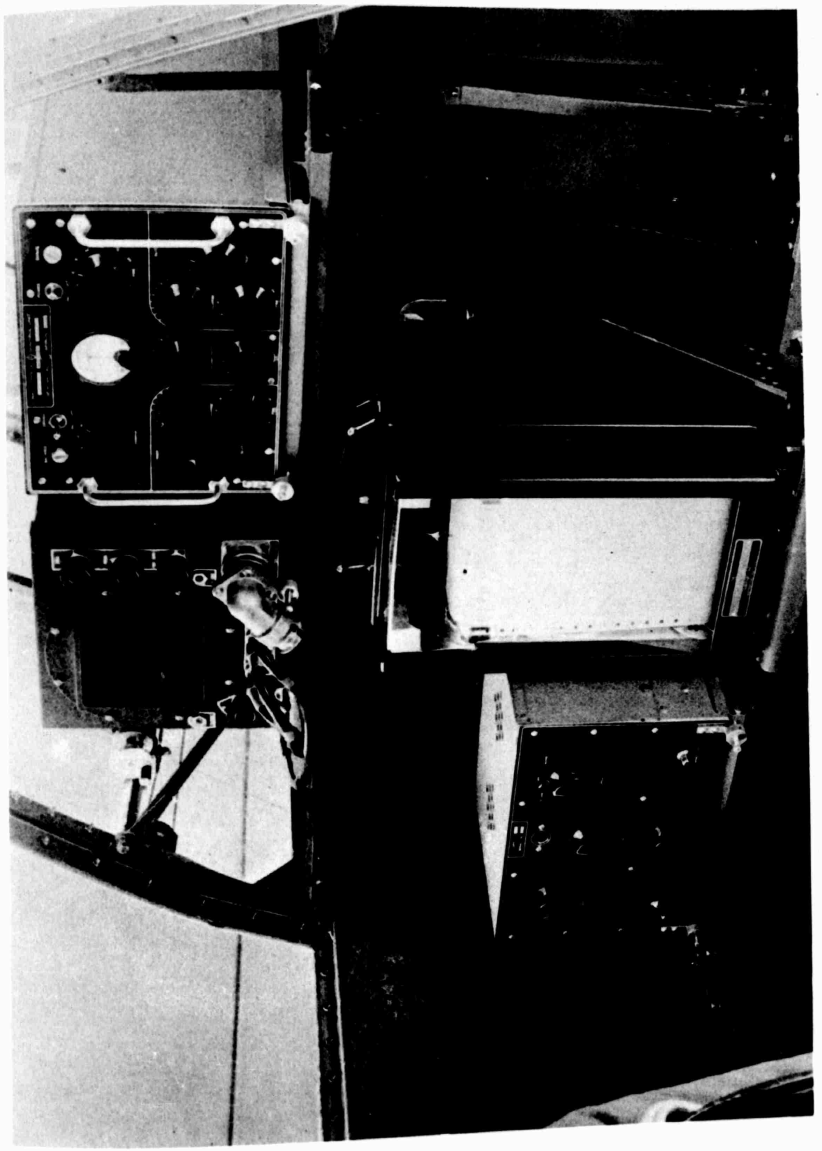
USE OVER WIDE RANGE OF MAGNETIC LATITUDE

The DT-1/ASQ-1 magnetometer head and motor assembly is not suitable for use in areas where the dip angle of the earth's magnetic field is near zero. A universal head and motor assembly DT-3/ASQ-1A, has been designed to operate at any magnetic latitude. No mechanical changes are necessary when the equipment is taken from one region to another. When this universal head and motor assembly is used, the complete system is designated AN/ASQ-1A. DT-3/ASQ-1A is shown in Figure 38.

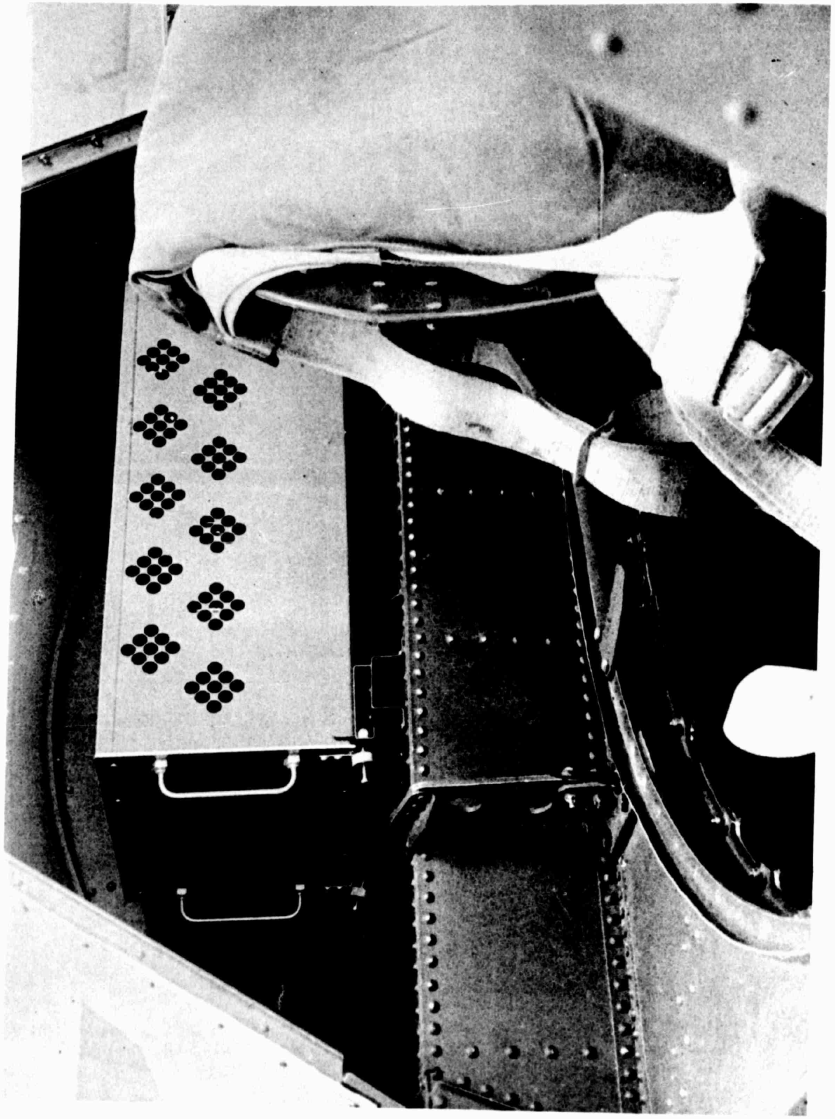
Figure 39 shows the magnetometer head in more detail. The detector element and the stabilizer elements are mounted together as in DT-1/ASQ-1 but the gimbal arrangement has three axes of rotation. Rotations of the detector and stabilizer elements about two axes are produced by two motors controlled by the outputs of the two stabilizer elements as in the DT-1/ASQ-1 unit. Rotation of the magnetometer head about the third axis is produced by a third motor in such a way that under no conditions are complete rotations required about either axis. The use of this ingenious system makes slip-rings or sliding contacts unnecessary. The motor end of the assembly is shown in Figure 40. Motion is transmitted from the motors to the magnetometer head by means of shafting and gears in contrast to the belts used in DT-1/ASQ-1. The weight of the DT-3/ASQ-1A unit, with its streamlined housing is 15 pounds.

The control circuit for the third motor is contained in the small unit, AM-9/ASQ-1A, shown in Figure 41. This unit is 7-7/8 by 5-3/32 by 12-1/8 inches and weighs 10 pounds.

The use of DT-3/ASQ-1A and the necessary addition of AM-9/ASQ-1A increases the total weight of a typical installation from 135 pounds to 151 pounds. Figure 42 shows the complete AN/ASQ-1A equipment.

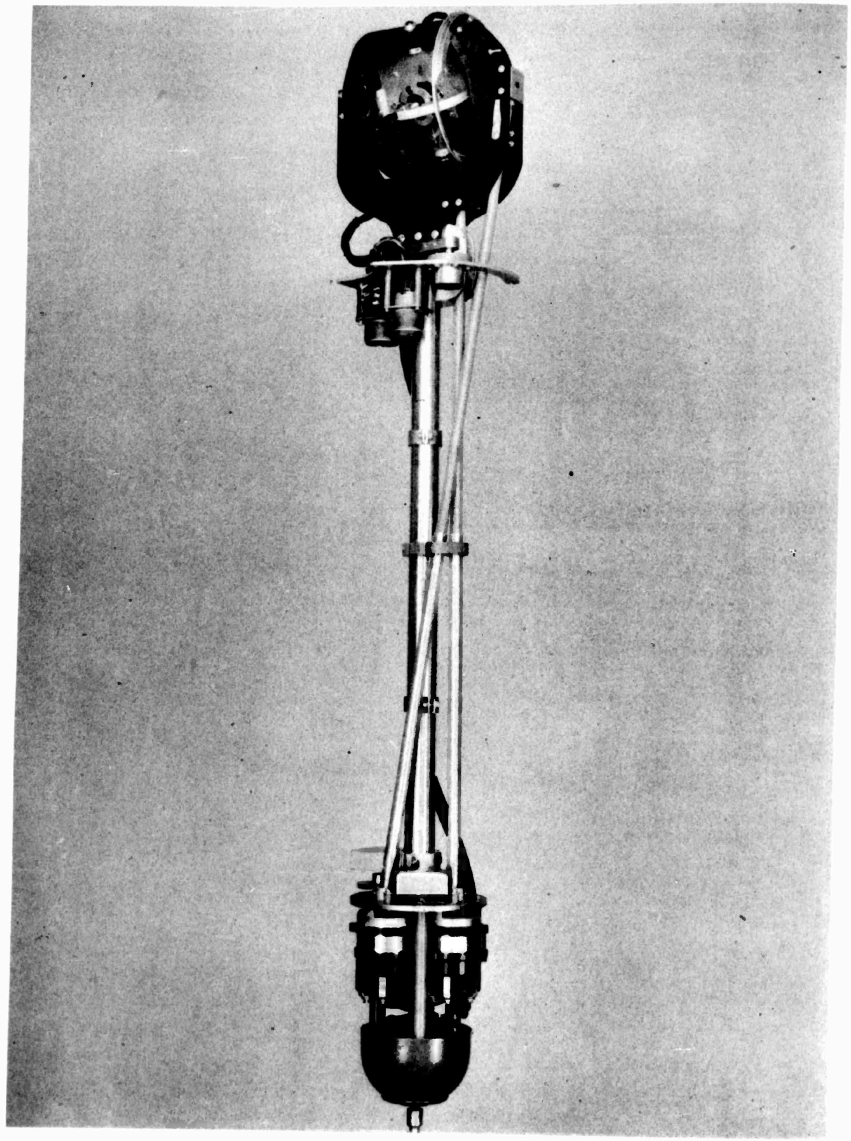


AM-1/ASQ-1 AND RECORDER INSTALLED IN TBF-1 AIRPLANE
FIGURE 35

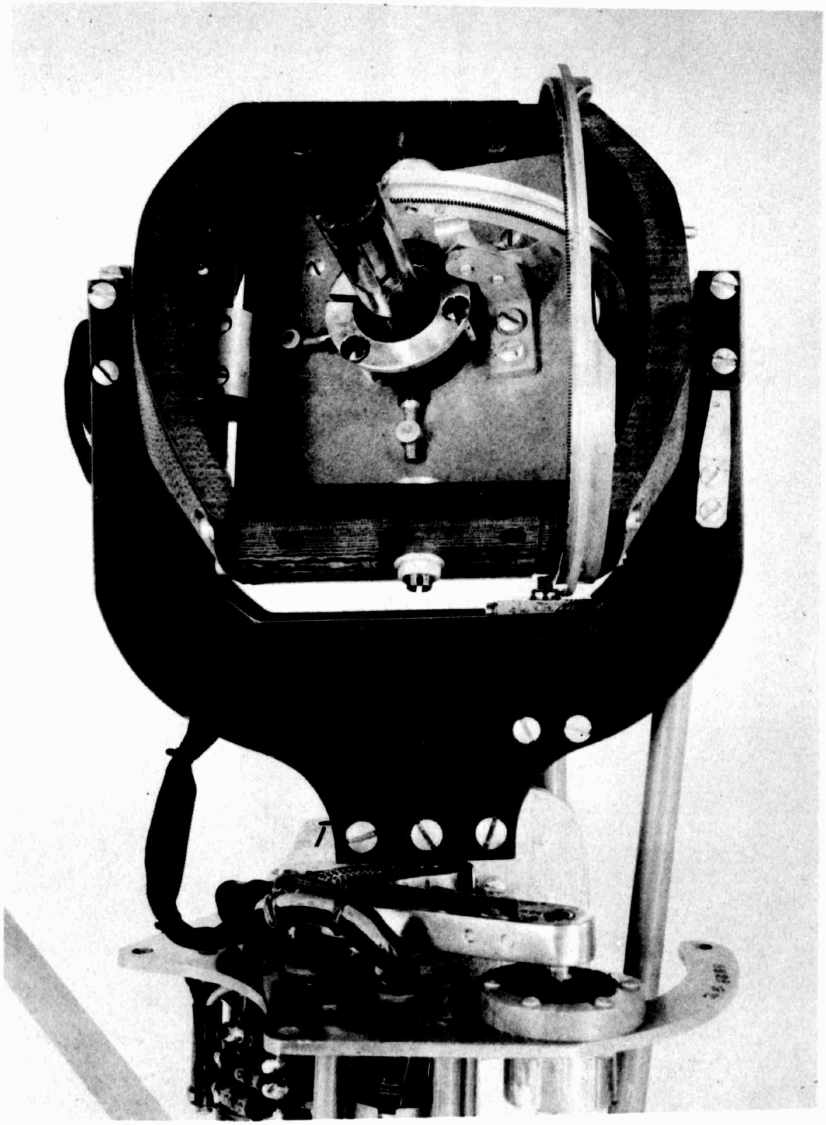


O-1/ASQ-1 INSTALLED BEHIND OBSERVER'S SEAT IN TBF-1 AIRPLANE
FIGURE 36

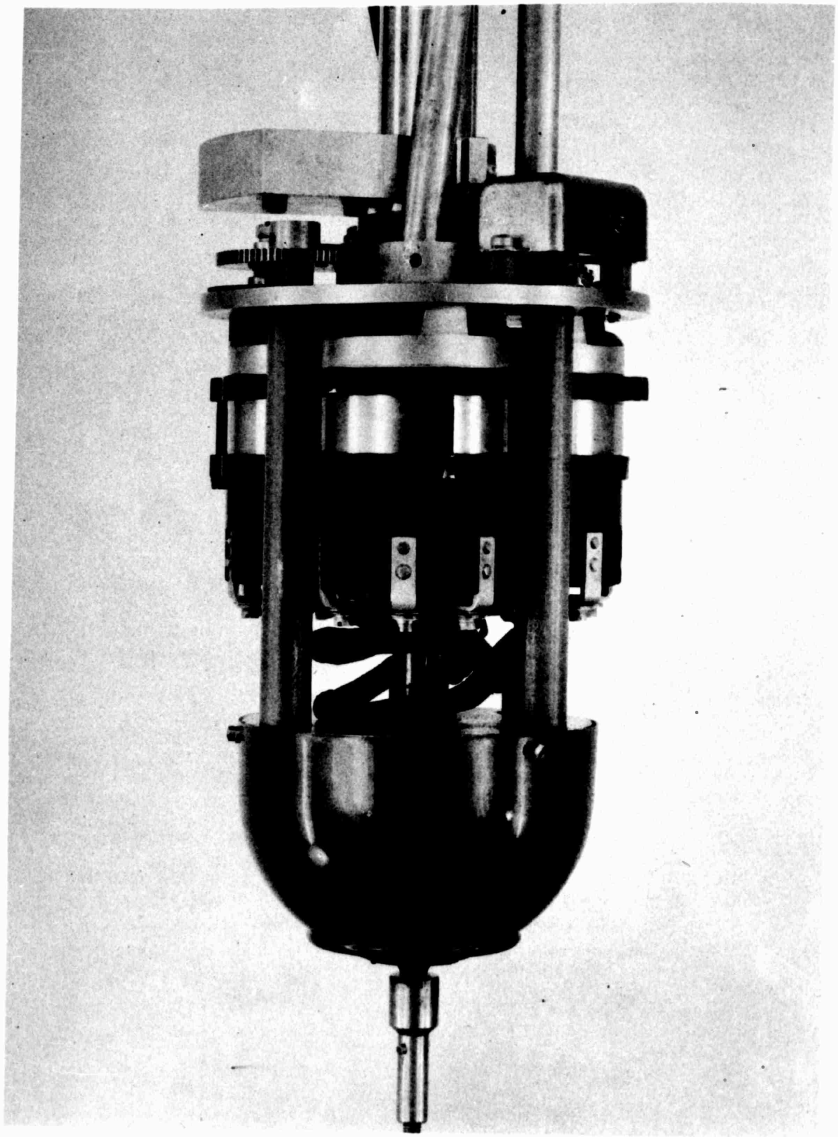
PILOT'S SIGNAL METER MOUNTED ABOVE THE INSTRUMENT PANEL IN A TBF-1 AIRPLANE
FIGURE 37



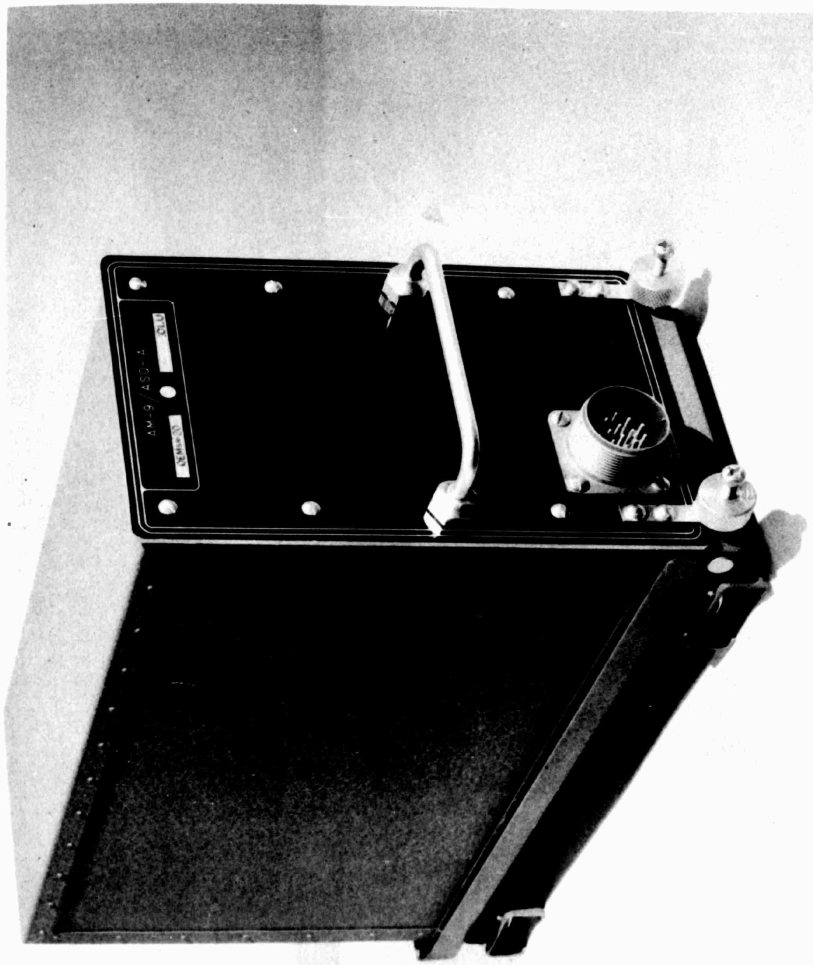
UNIVERSAL MAGNETOMETER HEAD AND MOTOR ASSEMBLY DT-3/ASQ-1A
FIGURE 38



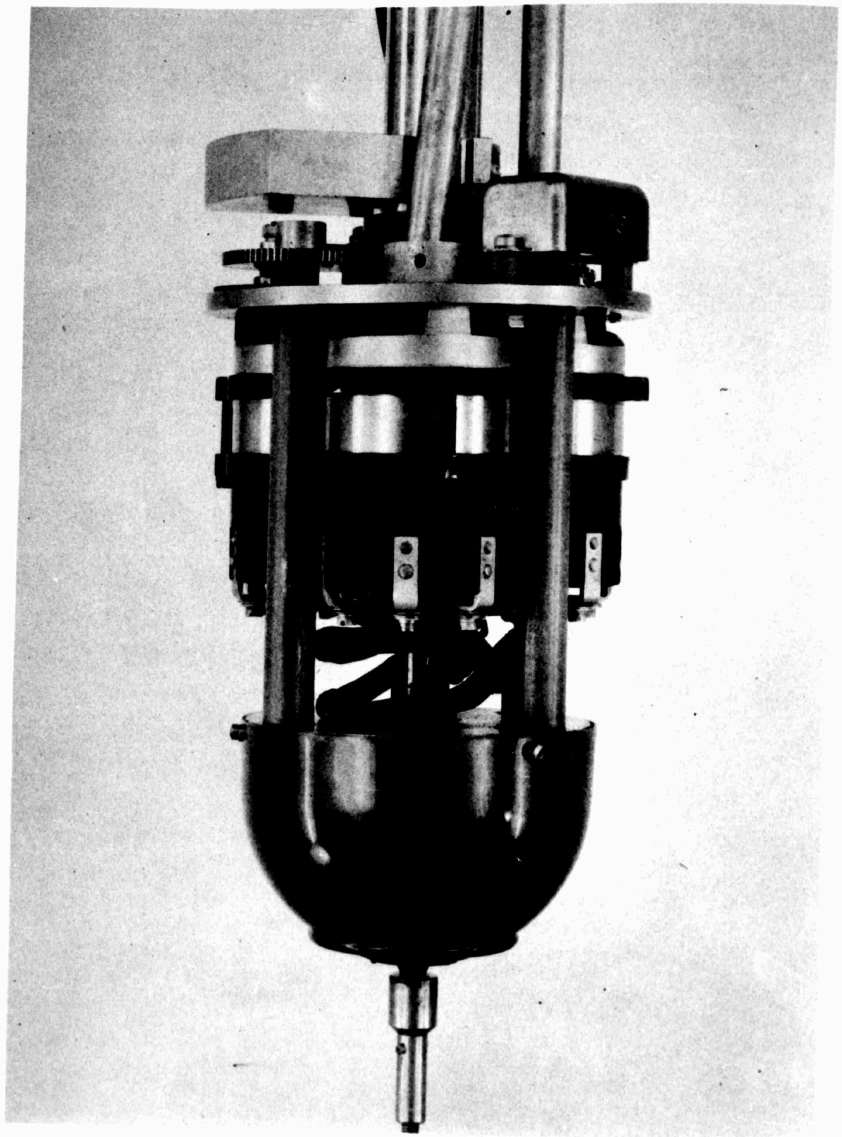
UNIVERSAL MAGNETOMETER HEAD OF DT-3/ASQ-1A
FIGURE 39



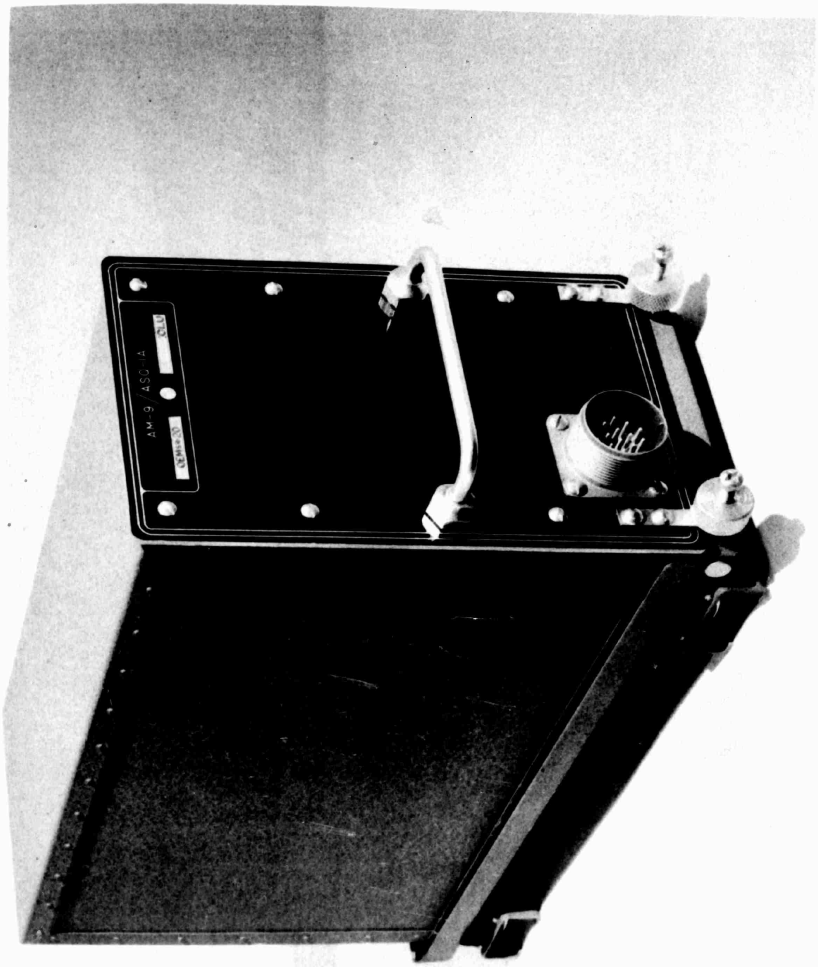
MOTOR END OF DT-3/ASQ-1A
FIGURE 40



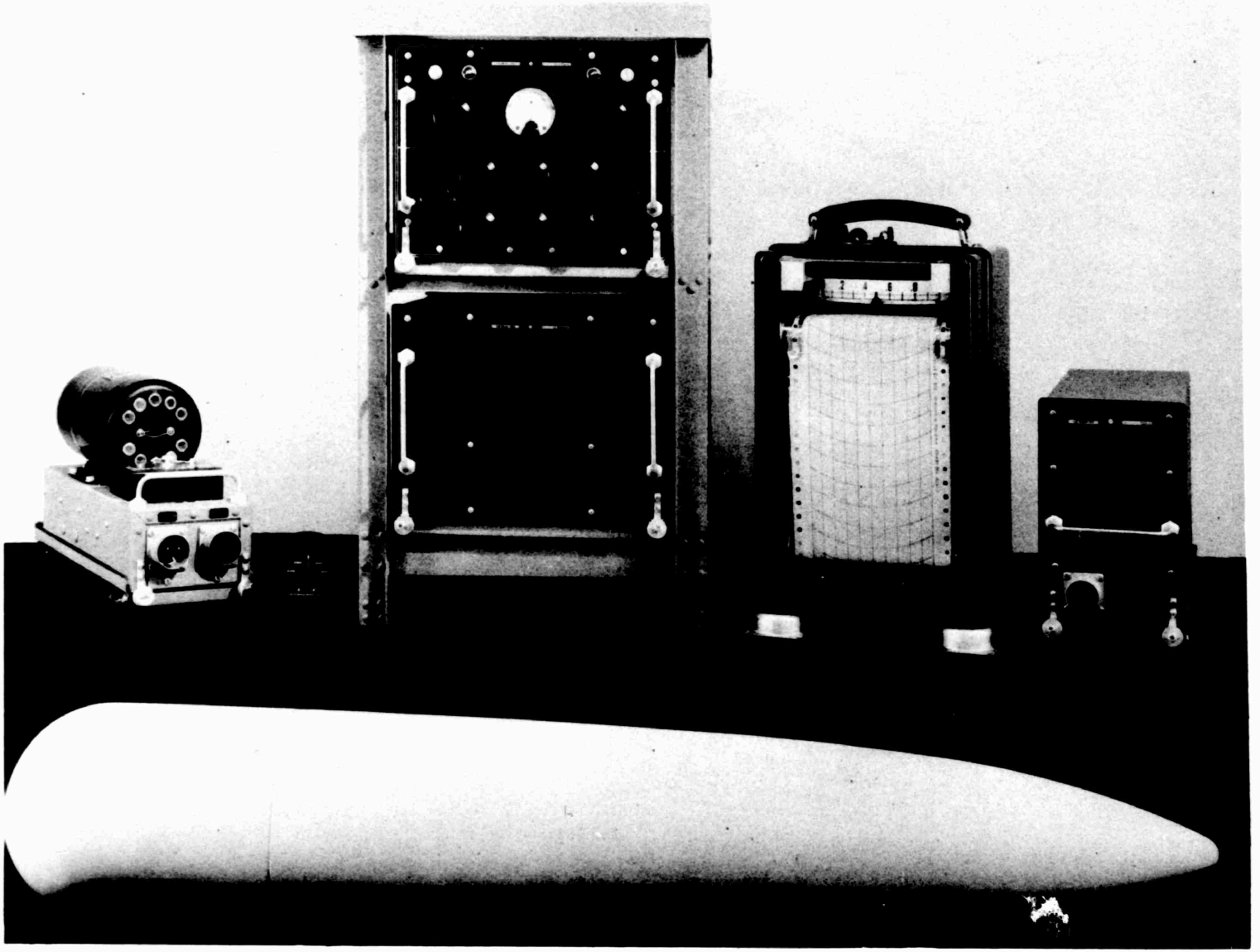
MOTOR CONTROL UNIT AM-9/ASQ-1A
FIGURE 41



MOTOR END OF DT-3/ASQ-1A
FIGURE 40



MOTOR CONTROL UNIT AM-9/ASQ-1A
FIGURE 41



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AN/ASQ-1A EQUIPMENT

FIGURE 42

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TITLE: AN/ASQ-1 Magnetic Airborne Detection Equipment

01895

AUTHOR(S): Ware, D. G.
ORIGINATING AGENCY: Columbia Univ., Airborne Instruments Lab., New York, N. Y.
PUBLISHED BY: Office of Scientific Research and Development, NDRC, Div 6

ATI- 31610
REVISION (None)
ORIG. AGENCY NO. (None)
PUBLISHING AGENCY NO. OSRD-2035

DATE	DOC. CLASS.	COUNTRY	LANGUAGE	PAGES	ILLUSTRATIONS
Oct '43	Confd'l	U.S.	Eng.	60	photos, table, diagrs, graphs

ABSTRACT:

The AN/ASQ-1 magnetic airborne detection equipment is discussed herein. The equipment is used to locate submerged submarines by detecting the small local changes produced by the submarines in the magnetic fields of the earth. The AN/ASQ-1 was designed on the basis of experience gained in the construction, testing, and operation of a substantial number of the previous models (MAD Mark IV-B2). The new equipment is smaller in size, lighter in weight, and comprises fewer individual units. Also all controls are on one unit, making it more convenient. Information pertinent to performance characteristics of the detector system and the stabilizer system is contained in graphic form, and photographs show the location of units in the various types of airplanes.

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DIVISION: Electronics (3)
SECTION: Components (10)

SUBJECT HEADINGS: Magnetic airborne detectors (58462)

ATI SHEET NO.: C-3-10-9

Reclassified per authority of OSRD
List 28 dtd Jul 1-5, 1946
by [illegible]

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(18) XC

(19) OSRD

(23) * Magnetic detectors
Submarine detection

(25) AN/ASQ-1

P 17/06